THE IMPACT OF AN ALTERNATIVE APPROACH TO TEACHING IN THERMODYNAMICS II USING SPREADSHEETS - A CASE STUDY

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THE IMPACT OF AN ALTERNATIVE APPROACH TO TEACHING IN THERMODYNAMICS II USING SPREADSHEETS - A CASE STUDY

For Masters in Education (Higher Education)

Faculty of Education

UKZN

THESIS

by G. Thurbon

DUT

Mechanical Engineering Dept.

Disclaimer :   The opinions expressed in this Thesis are not necessarily those of the Department or the DUT.

A dissertation submitted in partial fulfilment of the requirements for the degree of Masters of Education (Higher Education), in the School of Education and Development at the University of KwaZulu-Natal.

Supervisor: Dr. C. Mbali (University of KwaZulu-Natal)

February 2011

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14 December 2009

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ABSTRACT

Since South Africa's newly formed democratically elected Government in 1994 the face of South African education has changed across the board involving a paradigm shift from a content-based teacher-centred curriculum to outcomes based education (OBE), a learner-centred outcomes-based curriculum. This means that educators need to re-align their courses to that system and allocate appropriate resources to it. Hence the way one needs to go about educating learners has changed, and conversely, the learners themselves have had to face a change in learning tactics associated with the system.

In light of the above, this study was undertaken to test an alternative method of teaching and learning. The subject chosen was a second semester introductory subject, Thermodynamics II, having several follow-on courses at higher levels. It is a subject that for many years has been considered internationally to be a "difficult" subject by many who have been through the system and one that in later life still tends to attract the same response. The study was conducted at the Durban Institute of Technology (DIT), formed from the merger of two former Technikons, Technikon Natal and ML Sultan, in 2002, now the Durban University of Technology (DUT), since 2007. The class was a fairly representative mix of race groups and gender.

The study was a single case study, operating both within the positivist paradigm, the typical paradigm of scientific study, and the interpretivist paradigm, one in which students are often more involved in constructing meaning for themselves. The study was run over an eight week period, roughly the first term of a semester, covering the first few sections of the syllabus. The approach chosen was to halve the number of conventional chalk and talk lectures over that period, and using a constructivist approach to learning, to replace them by interactive computer laboratory sessions whereby students learnt the theory for themselves whilst at the same time using it to generate spreadsheet exercises to solve typical Thermodynamics problems. The idea was that students actually interacting with the basic requirements of the subject would hopefully develop a deeper level of understanding for the subject. The second term of the subject was handled in the typical manner of conventional lectures.

There were three main interventions undertaken during the study period, namely two spreadsheet assignments undertaken using Excel, a student study habit survey and a concept test. Towards the end of the semester nine students from the class were interviewed. Each intervention is explained below.

For the two spreadsheet assignments, a constructivist approach was taken with students working in groups of three to design the spreadsheets, the first to solve for the work done for any three consecutive processes forming a cycle, drawing the cycle on a pressure-volume graph. The second spreadsheet assignment was to be able to solve any problem associated with the non-flow energy equation and the steady flow energy equation, for any one unknown. At the end of each assignment each group had to peer assess one other group's spreadsheet by using it to solve a problem. They then had to assess it guided by a rubric, considering criteria taken from the subject's learning outcomes, writing down any good points and points for improvement.

The study habit survey was a single page, two sided survey questionnaire, answered mostly using Lickert type scales and was handed out during one of the computer sessions. There were six main sections, namely personal information, information exchange, library use, subject specifics, practical experience/exposure and study techniques. A section was left at the end for students to fill any other information they wished to add. SPSS was used to analyse the information using cross tabs.

The concept test was designed by the Researcher in Quattro Pro and was a multiple choice type questionnaire. It automatically marked the test by adding up the correct answers, giving the student immediate feedback at the end of the test by providing a percentage score for each of the four questions asked and a percentage score for the test as a whole. The test questions were based on the principles and methods that students would have used in the setting up of the computer spreadsheet exercises.

The interviews were conducted individually for each student using a semi-structured approach. They were then transcribed and analysed using Transana. The information gathered from these, combined with information from the other interventions were triangulated where appropriate.

Further, the two main intervention semester test scores were compared to each other using SPSS. Previous semester test scores were used as a control group and were also compared to the intervention semester test scores. Although the marks attained in the intervention semester did not show any major improvement when compared with other semesters, it did show that alternative methods of teaching and learning can be implemented within the mark norms. The study habits survey provided information about student preferences which will be helpful in future attempts at improving teaching and learning in this branch of engineering in this institution.

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There are numerous people who have helped me in many different ways to enable me to complete this project and write up this thesis. To them all I am extremely grateful and wish to express my sincere thanks to all of them no matter how small or large a part they may have played, because without them I would not have been able to undertake this study.

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My colleague Sfiso Radebe, who acted as my assistant interviewer on numerous occasions.

My students at the DUT who put up with my endless requests and explanations and who have provided me with feedback necessary to undertake the project.

Other staff, colleagues and friends have also assisted to enable this to occur. If I do not mention their names individually I trust that they will forgive me. However, a few need to be mentioned personally:

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GLOSSARY OF TERMS (including abbreviations)

CELT	Centre for Excellence in Teaching and Learning
CHE	Council on Higher Education
CHES	Centre for Higher Education Studies (At DUT, now replaced by CELT)
CHET	Council on Higher Education Transformation
DIT	Durban Institute of Technology (created from the merger of TN and ML Sultan in 2002)
DoE	Department of Education
DUT	Durban University of Technology (replaced the DIT in 2007)
EBE	Faculty of Engineering and the Built Environment
ECSA	Engineering Council of South Africa
ESBE	Faculty of Engineering, Science and the Built Environment, now EBE
HEP	Higher Education Practice, Module 1 of MEd.
HEQC	Higher Education Qualifications Committee
HEQF	Higher Education Quality Framework
NFEE	Non Flow Energy Equation, used to analyse closed systems in Thermodynamics
NQF	National Qualifications Framework
OBE	Outcomes Based Education
SAQA	South African Qualifications Authority
SFEE	Steady Flow Energy Equation, used to analyse open systems in Thermodynamics
TN	Technikon Natal
UKZN	University of Kwa-Zulu Natal
UWC	University of the Western Cape
WebCT	Web Course Tools
WIL	Work Integrated Learning, a one year practical in-service training component of the National Diploma:Engineering:Mechanical

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Only three students took a multiple approach to check their answers, the others using only one comparison. However, as this was under interview questioning, one has to

CHAPTER 1

BACKGROUND

1 Overview of Dissertation Layout

This dissertation thesis is set out in five chapters. The first chapter provides a national and local context with some rationale for the project. It then looks at how the subject, Thermodynamics II, currently runs and finally mentions some traditional teaching methods.

Chapter 2 introduces the main research questions for this project. It provides a focus for the study by looking at students learning and studying habits and then introduces a background to computer assisted teaching, including the use of spreadsheets. It then introduces some of the problems other researchers have found students have in studying thermodynamics.

In Chapter 3 the study itself is introduced, differentiating between the methodologies of the research paradigm and the teaching and learning paradigm. It also discusses the details of each intervention, the assessment methods and mark allocations, comparing them with a normal semester.

Chapter 4 provides an analysis of the data, both qualitative and quantitative. Finally, Chapter 5 provides some conclusions associated with the analysis, together with further research possibilities and developments.

1.1 Introduction

This thesis is based on experiences gained in the teaching of Thermodynamics II at the Durban University of Technology (DUT), previously the Durban Institute of Technology (DIT) and formerly Technikon Natal (TN), over a period of approximately fifteen years.

(Sprackling, 1993, p.viii) writes of thermodynamics:

> Thermodynamics is one of the major subjects of classical phenomenological physics, a
> subject of great power and beauty. Nevertheless, it is, for many students, a difficult

subject and one that they do not understand on a first (and often, only) reading. To them the subject seems to be a collection of subtle concepts, linked by countless equations with no underlying framework.

Having listened over the years to what students, colleagues and fellow engineers say about the subject, the quote above rings a common bell on occasions when the subject is mentioned. Often the way a subject is taught can have a big impact on the way it is perceived. This creates a long lasting impression, as witnessed frequently by people's reactions at the mere mention of the subject, even if they studied thermodynamics many years ago.

Traditionally it is taught in a very conventional way, consisting of lectures, interspersed with tutorials and backed up by laboratory work. In recent times new teaching methods and learning styles have been developed and are now accepted as alternative approaches. The advent of the personal computer in recent years, together with its rapid growth in speed and power, has also opened up new avenues of opportunity to use the personal computer as another weapon in the arsenal available to lecturers and students alike.

This study was initiated to undertake an alternative approach to teaching the subject Thermodynamics II, utilizing computer spreadsheets as a tool to involve students in an active learning environment. Several other associated exercises were run in parallel with this to gain an insight into student learning habits.

1.2 SAQA and the NQF

1.2.1The changing education background

Since its first democratic election in 1994, the South African Higher Education system has been in a state of flux as it moves out of the apartheid era dominated by "white Western male"(Breier, 2001, p.1) authority, with an "elitist higher education"(Council On Higher Education, 2004a, p.95) system, to a system that will "Accelerate the redress of past unfair discrimination in education, training and employment opportunities" as stated in the objectives of the National Qualifications Framework (NQF) (South African Qualifications Authority, 2000a), p.4}. At the same time it needs to take into account the external influences of massification, internationalisation (Breier, 2001, p.1), and globalisation (Council On Higher Education, 2002, p.2; Young, 2001, pp.19, 39; Cloete et al., 2002, p.448).

The emphasis on how the teaching and learning takes place has shifted to an outcomes based education (OBE) system, regulated by the National Qualifications Framework (NQF), with quality control administered by the Council on Higher Education's (CHE) Higher Education Quality Committee (HEQC), under the terms of the Higher Education Act of 1997 (Department of Education, 1997). This Act has pulled all the previously separate education bodies into one system from primary all the way to tertiary level, partly in an effort to "bring academic education and vocational training into closer alignment" (Council On Higher Education, 2004a, p.95). In April 2010 the Department of Higher Education and Training (DHET) became an independent governing body (DHET 2010, p.12) separate from the Department of Education (DoE).

1.2.2 OBE and the NQF

The outcomes based education (OBE) system is a paradigm shift away from the previous education system. OBE looks at outcomes and developing an education system to "build a 21st century system of education and training." (South African Qualifications Authority, 2000a, p.15) encompassing all the population groups.

1.2.3 HEQF and ECSA

Within the new NQF system, there is a quality controlling body, the Higher Education Quality Committee (HEQC), administered by the Council on Higher Education (CHE). It requires institutions to set up a quality management programme "to monitor, review and improve its programmes and courses" (Council On Higher Education, 2004c, p.24), guided by the CHE's Improving and Teaching Learning Resources 1 and 2 (Council On Higher Education, 2004b, 2004c). Recently merged institutions were not to be audited until "the second half of the first audit cycle (2007-2009)" (CHE, 2005, p.2), this task being undertaken by the DUT in August 2007.

The CHE, operating within the Higher Education Quality Framework (HEQF), as promulgated by the Department of Education (DoE) Higher Education Act of 1997 (Department of Education, 1997), also has the task of accrediting engineering courses and administering quality therein. The HEQC, who oversees this operation, has tasked the Engineering Council of South Africa (ECSA) to perform the function for the Engineering Fraternity. ECSA originally

undertook the registering of the Mechanical Engineering Diploma with SAQA on behalf of all the Higher Education Institutions, the Diploma being reregistered with SAQA in 2009 (SAQA, 2009).

As such, ECSA accredited the DUT (formerly the DIT) Mechanical Engineering Department's Programme in August 2005 (Kanny & Thurbon, 2005), a process that takes place every four years. It should be noted that although the new OBE system is in place nationally, the move to this new curriculum as specified and utilized in the preparation of this thesis, is still under way. Thus the OBE System is not completely entrenched and work still needs to be done on a new accreditation programme, which was due for completion in 2008 (but is still to be started in 2009).

1.2.4 The new National Funding Framework

Alongside the new centrally administered system of education is the new Funding Framework Policy (Ministry of Education, 2004). This differs from previous funding policies for Tertiary Institutions, in that it considers the throughput (in the minimum specified time for a course) of an institution, and analyses "each institution's student output performance in the context of approved national benchmarks" (Ministry of Education, 2004, p.3). That is, the funds issued to a Tertiary institution in the future will be partly dependent on the number of students who graduate in the minimum required time for any particular programme, which could have a serious impact on all Tertiary Institutions' funding in South Africa. The target currently set is for a minimum of 22,5% throughput in any programme to fall in line with the funding allocations.

1.3 Departmental pass rates and issues of concern

In some subjects, Thermodynamics II included, the pass rate is often less than 60%, a figure designated by the then Deputy Vice-Chancellor:Academic as a minimum expected pass rate in any subject, with a report to be submitted to the HOD if the pass rate was below this figure. This is in excess of the typical current pass rates, which have been on the decline in recent years. This pattern is also true in other subjects for various reasons.

Some of the factors that may have contributed to the decline in pass rate could have arisen from providing greater access to institutions as promulgated in the South African Qualifications

Authority Act of 1995, s. 2. Institutions are now accepting more under-prepared students (Hay & Marais, 2004, pp.59, 62; Nair, 2002, p.95). English second language students and recent Academic Literacy requirement changes (McKenna, 2003, p.64) have increased student access. A lack of available funds for students to cover their tuition fees, residence fees, books, transport and other incidental costs is an ongoing problem. This could influence and, in some cases, exacerbate other problems. In a study of DUT students by Pillay, T. and Wallis, M. (2009, p.70) "52% (287 of the 551 respondents) sited financial problems as the reason for dropping out In a study conducted by the HSRC (Letseke and Maile, 2008, p.7) on the dropout rates in higher education between 2000 and 2003, only 22% of students graduated in the minimum time, 50% dropping out within the first two years and the remaining 28% were still in the system but hadn't completed. Concerning the DIT, the 2005 to 2007 period saw the dropout rate in the Faculty of Engineering and the Built Environment at 54%, the highest in the University, with the throughput rate (students who graduate in the minimum time of three years) as the lowest in the University at 6,58%, the average for the University being 23,6% (Pillay & Wallis, 2009, p.56).

1.4 Overview of assessment in Thermodynamics II

If the subject is broken down into its major assessment components, as seen in Table 1.1 below, it is noted that each component contains a fairly large portion of the semester mark.

There are certain sub-minimums along the way that qualify a student to progress, as seen in Table 1.1. The main one that limits eligibility to write the exam is departmental rule EM8.2, pertaining to obtaining a class mark sub-minimum of 40% (Durban Institute of Technology, 2006a, p.8). There is a further requirement that a minimum mark of 40% be achieved in the

TABLE 1.1: Summary of mark weighting and allocations for subject lectured

Assessment	Thermodynamics II -normal semester	Sub-minimum Requirements
Test 1	30	None
Test 2	40	None
Practical	30	None
CLASS MARK	100 x 0,4 = 40%	40%
EXAM	100 x 0,6 = 60%	40%
FINAL MARK	100%	50%

examination as well, G14(2), except when determining eligibility for supplementary examinations (Durban Institute of Technology, 2006b, p.32). The class mark and exam mark, with their unequal weighting of 40:60 then provided a final grade for the subject. This is standard for most engineering programmes run at the DUT.

The assessment mentioned above consists of writing two summative tests (Rowntree, 1987, p.121; South African Qualifications Authority, 2001, p.26), counting 70% of the class mark (see Table 1.1 above). The rest of the class mark is a combined averaged mark of several Thermodynamics laboratory practicals, which constitute the final 30% of the class mark. The class mark itself counts 40% towards the final mark. A summative exam at the end of the semester accounts for 60% of the final mark, as mentioned previously, and seen in Table 1.1. Thermodynamics is taught from a "scientific" perspective, putting it well within the traditionalist (technical) domain of curriculum theory, as defined by Habermas' "knowledge-constitutive interests" (as cited in Luckett, 1995, p.27, Grundy, 1987, pp.10-12). McKenna (c. 2003, p.6) states that the "technical interest is served by the generation of laws allowing control of the environment", and labels it as a positivist paradigm. Considering Thermodynamics II, and the way it is taught and assessed by the Researcher (a Positivist by nature), clearly places it in this traditionalist paradigm, whereby the learner often employs a surface learning approach (Luckett, 1995, pp.31-33).

1.5 Lecturing style

The subject Thermodynamics II is presented to students in a structured manner as the progression of the subject follows a logical sequence. The terminology, laws, rules and processes of thermodynamics (i.e. the basics), are introduced first as these are required throughout it and all other subsequent associated subjects. The rest of the subject deals mainly with application of the basics and how substances behave and are analyzed according to the basics. There are four lectures and one tutorial per week, backed up by hands-on laboratory practicals designed to reinforce class theory.

The style of lecturing used by the Researcher has changed over the years and currently tends to follow "the inquiry method" (Postman & Weingartner, 1971, pp.38- 47), typically answering questions with more questions. This is not always popular with students, but is designed to get them to think through the problem themselves.

1.6 Traditional teaching methods

1.6.1 Lectures as a learning environment

Lectures are the predominant form used for the transfer of knowledge to students and are discussed in Chapter 2.2.1. Like any method they are both useful but at the same time problematic in that they do not always achieve their desired output.

In the Researcher's recent experience, the fact that there are more people listening in has had an effect on the group dynamics. Those who are not listening in, or possibly even tuned out, can play an active role in disturbing those who are trying to participate in the lectures. This has become more evident in recent years when classes have become noisier and more disruptive in all subjects. Cellphones are another unwelcome influence in lectures, with students leaving their phones on and answering calls during lectures, taking pictures continuously, typing messages on MXit, and so on. This has led to much debate of what is being termed as cellphone etiquette (Lipscomb, et al., 2005, pp.48). Another increasing problem is that class attendance has been dropping, either due to boredom, finances, transport or registered students never attending because they are working at outside jobs. As a result, lectures are not as effective or efficient as they should be, and supplementary information passed on during lectures is often never received.

1.7 The students

1.7.1 Who are they

The student demographics in Science Engineering and Technology at the DUT (Pillay, T. and Wallis, M. (2009, p.52) are fairly representative of the country as a whole (SouthAfrica.info reporter, 2007), with Indians being more numerous than national norms due to past immigration policies into Natal. They come from all walks of life encompassing different ethnic, cultural and religious backgrounds. They have different expectations of University and the life on the Campus, often being disappointed by the realities of the situation. Many do not understand the rules that they are expected to abide by and often end up facing difficult situations because of this. This is highlighted by the increase in student academic disciplinary cases within the institution, as seen in Appendix V, a number of which fell within the Mechanical Engineering Department, including some of the students, in the 2007 cases, who had participated in this

research project. By far the majority involve cheating and plagiarism. These are on the increase both locally and internationally (Heywood, 2000, p345-346). Another problem which is becomes a problem is using cell phones to cheat, especially in examinations.

Student**s** get accepted to the DIT after matric (at least 12 years of schooling), so they would be at least 18 years old and some older if they have had repeat years**.** As with higher education throughout South Africa, and in most of the world, students at the DIT are treated as young adults capable of independent thinking and making choices about their priorities and use of time**.**

1.7.2 Practical experience

Although work integrated learning (WIL) is a part of the Diploma course, it is often only undertaken towards the end of their studies at the University. As such many do not have exposure to plant and operations thereon until after their studies. Hence they do not appreciate the practicalities of plant and operation and cannot relate class theory work to real life situations.

1.7.3 Facilities and resources available to them

The University has various facilities available to students for their studies. This includes on-Campus accommodation, Cafeterias, open access computer laboratories, a large Science and Engineering Library and various Departmental and other laboratories, all on the Steve Biko Campus, some of which are supervised venues. There is also an internet café located off-site. Some of these sites contain additional resources, such as books and computers, besides their main function.

Further to this there are other facilities on Campus including the Isolempilo Wellness Centre to assist with medical problems, a student counseling centre assisting in career and personal guidance and a financial aid centre to assist with finances. There is also a Student Representative Council (SRC) whom students can approach to help them on various matters concerning campus life and other assistance they may require from time to time.

1.7.4 Learning Theories

There is growing interest in the techniques students use to learn, and "There now exists an

extensive body of knowledge not only on theories of learning and cognition but also on learning in HE, and specifically on the teaching and learning of particular disciplines in HE." (Council on Higher Education, 2003, p.11). Some of these will be discussed later in Chapter 2.1. This type of research has been done in many fields of science including Thermodynamics (Speich, Mclesley, Richardson, & Gad-El-Hak, 2004, p.1023; Loverude, Kautz, & Heron, 2002, p.137). With increased awareness of these theories, the Researcher grasped the opportunity to investigate how far they could be applied to the students within this research project. Some are detailed in Chapter 2.1.

CHAPTER 2

THEORETICAL RATIONALE

2 Introduction

The Researcher's interest in teaching and learning was sparked whilst participating in a two day workshop on Effective Teaching, mainly in engineering and science by Felder and Brent in 1999. This, together with the changing scene in South African education to the new OBE system, since the first free and fair elections in1994, generated a desire to know more about this field. In proceeding through the Masters in Higher Education several subjects were introduced to the researcher broadening his ideas about teaching and learning.

In the introductory course to the Masters, HEP1, which gave a broad general look into many areas of tertiary education, many styles of presentation were introduced to the Researcher. These ranged from formal approaches such as lectures (chalk and talk) to both small and large groups, assignments and practicals to more informal methods such as group discussions, videos and tutorials. Two other subjects that had a great influence on this research project were Assessment and Curriculum Development.

One of the first modules undertaken after HEP1 was Assessment. This introduced the Researcher to alternative ways to teach and assess the work covered. When it comes to assessment again there are various methods that can be used. Some of the ways of assessing student work are by summative written tests and examinations, practical tests, both hands on and oral questioning, which were already being undertaken by the Researcher before this study was undertaken. However, other methods were introduced to the Researcher during the module such as self and peer assessment. Here learners get more involved in the assessment, providing more input to the mark allocation. All of these methods affect the students learning and their approaches to learning.

Later on the module Curriculum Development provided the Researcher with a more in depth look at the theories behind curriculum development, where current curriculum sits and what influences curriculum development. It also gave the researcher an insight into which paradigm

of teaching and learning he sits in relation to Habermas' knowledge constitutive interests, namely the "Technical Interest " (as cited in Luckett, 1995, p.27; Grundy, 1987, p.11), which can briefly be summarised as "*a fundamental interest in controlling the environment through rule-following action based upon empirically grounded laws*" (Grundy, 1987, p.12). In this paradigm people have a "basic orientation towards controlling and managing the environment" and Habermas relates this interest to the "empirical-analytic sciences" in which knowledge is established by "experience and observation, often produced through experimentation" (Grundy, 1987, p.11). This paradigm is equated to the positivist paradigm, introduced in Chapter 3.2.1. Habermas' other two knowledge constitutive interests are the "*Practical Interest*", defined as "*a fundamental interest in understanding the environment through interaction based upon a consensual interpretation of meaning*" (Grundy, 1987, p.14), which relates to the Interpretive Paradigm, introduced in Chapter 3.2.2, and the "*Emancipatory Interest*", which can be described as "*a fundamental interest in emancipation and empowerment to engage in autonomous action arising out of authentic, critical insights into the social construction of human society*" (Grundy, 1987, p.19).

Chapter 2 thus provides a theoretical rationale as all these modules of the Masters in Higher Education had a big influence as to how this study was developed and eventually undertaken. The theoretical background associated with each question in the Thesis (one main and three sub-questions) is presented below the question. The main question deals with student learning and modes of knowledge delivery. Then the next two sub-questions are presented dealing with how students go about learning Thermodynamics II and the problems they face, both within the subject and in a more general sense. Finally the third sub-question deals with how the intervention was assessed and how it was analysed as compared with the norm.

How does delivery affect student understanding? (Main question)

Part of this project was to see how students would react to a different way of teaching and learning. In order to accomplish this a different style of teaching was adopted for the first half of the semester (roughly Term 1), the rest of the semester (mostly Term 2) being devoted to more conventional lecturing techniques, as used by most other lecturers in the department.

Before discussing delivery it is necessary to explain some of the researched features of learning.

2.1 Learning

Learning takes place on a continuum and is an ongoing process that never stops (South African Qualifications Authority, 2000b, p.25). In many Higher Education Institutions, although the norm is the formal lecture, discussed in Chapter 2.2.1, in which students are often "passive recipients" (Ramsden, 2003, p.108), learning can also take place when students interact with each other in group situations, discussed in Chapter 2.2.6, such as in discussion and demonstrating their skills on computers to each other, discussed in Chapter 2.2.4.

Ramsden (2003, p.6) suggests "that we can improve our teaching by studying our students' learning". He goes on to suggest that learning from a student's perspective does not imply the simple regurgitation of facts and figures, but requires "a qualitative change in a person's view of reality" (ibid, p.7). Kolb (1984, p.38) defines learning as "the process whereby knowledge is created through the transformation of experience".

Researchers have been studying different approaches to learning for a number of years and many theories have been put forward about how people learn. What has been realised is that there is no definitive theory to cover all aspects of learning. There are many variables that need to be taken into account if one is to propose a model of learning. It also depends into which paradigm, discussed in Chapter 3.2, one considers learning.

Theories about how students learn have been developed, some being proposed as learning styles. The term 'learning styles' is one of a series of similar phrases used by various researchers to describe a body of research that has drawn "on the fields of pedagogy, psychology and neuroscience" (Fleming, 2008, para.1). It tries to describe the way in which students and others go about the task of learning. One of the most widely ranging recent studies attempting to review many of these learning styles and Inventories, mainly in the Higher Education and adult learning arena, has been the report of Coffield, Moseley, Hall and Ecclestone (2004a), discussed in Chapter 2.1.4.2. There is much disagreement about the usefulness and effectiveness of learning styles. Coffield, Moseley, Hall and Ecclestone (2004b, p.11) describe it as "a field which is marked by disunity, dissension and conceptual confusion." Felder and Brent (2005, p.58) says of learning styles that one "is neither preferable nor inferior to another, but is simply different, with different characteristic strengths and weaknesses".

These theories have led to models of learning into which students can be classified or grouped.

To enable one to be associated with one of the models typically requires the taking of a test. These are usually multiple-choice, often performed on a web page associated with the designer of the test. Several of the tests and their associated designers will be mentioned later in this chapter.

Learning cycles, such as Kolb's as detailed in Chapter 2.1.5, themselves models, have developed alongside learning theories and models. They typically look at how one goes about learning so that it re-enforces the process, hopefully leading to a deep learning process.

Closely allied with learning styles are the study habits that students utilize in the processing of the information received during learning activities. These are considered at the end of this section.

2.1.1 Approaches to learning

It is only "in the past twenty years or so" (Biggs, 1999, p.11) that researchers have delved into the way students learn, developing further on Marton and Säljö's work of defining students' approaches to learning as surface or deep (Ramsden, 1992, p.46; Atherton, 2005a, para.1; Case & Marshall, 2004, p.606; Higher Education Practice 1, 2004, pp.4-5 (session 2)). Entwistle and Ramsden (as cited in Higher Education Practice 1, 2004, p.5 (session 2)) have extended Marton and Säljö's work to include two further approaches to learning, strategic and non-academic.

In relation to categorising students as surface or deep learners, one must be aware of labelling students (Case & Marshall, 2004, p.606). Students may use the approach they consider appropriate to the assessment, hence they may move from one type of approach to the other depending on the type of assessment (Entwistle, 1988, p.106; Ramsden, 2003, p.49). Entwistle (as cited in Case & Marshall, 2004, p.607) suggests that the deep and surface approaches may also be disciplinary dependent. External components of learning such as "work load, the structure or presentation of learning materials, forms of assessment or time constraints all contribute. "Limited resources may also affect the issue – for example the lack of textbooks" (Higher Education Practice 1, 2004, p.5 (Session 2)).

Case and Marshall (2004, pp.613-614) suggest that the dichotomy of surface and deep is too extreme, and that there exist further approaches to learning in between these two extremes.

Students may use these further approaches depending on "their perceptions of the course context".

Understanding the many theories about how students study, and what factors, both internal and external, affect them, is a complex task. One is left wondering where to start in finding out in which theory a student is currently operating. A diversified multi-lingual, multi-cultural population in any given class, adds a further dimension to the possible factors that affect one's learning. Chickering and Reisser's (1993) summary of "relevant student development theories" and Coffield et al's (2004a) analysis of "13 of the most influential models" , mentioned in Chapter 2.1.4.2, were developed overseas in first world countries. Applying them in a third world context creates further tension as to which factors become relevant or dominant to the individual student. Heywood (2000, p.207) also suggests that different values possessed by teachers and students can also hinder learning.

2.1.2 Deep and surface learning

In a study, by Marton and Säljö, some students approached a task by trying "to understand the author's message by searching for connections within the text, looking for an underlying structure, or by relating the text to something in the real world or in their previous reading" (as cited in Ramsden, 1992, p.42). In other words they were attempting to engage with the text, not just literally, but in relation to the deeper meaning hidden within the authors' choice of words.

In the same study other students "skated along the surface of the text" (as cited in Ramsden, 1992, p.41). The students were simply "focused on the text itself, trying to memorise as much as possible" (Case & Marshall, 2004, p.606) without trying to understand the deeper meaning contained within the text. Students are often motivated by "**fear of failure**" (Atherton, 2005a, para.4) and try to give the teacher what they think he or she wants to hear or see.

2.1.3 Strategic and non-academic

Entwistle, Hanley and Ratcliffe (1979) (as cited in Heywood, 2000, p.223) identified this approach to learning in a pilot study. Atherton (2005a, para.3) describes it "as a very well-organised form of Surface approach, and in which the motivation is to get good marks". Students adopting this approach combine deep and surface strategies to achieve good grades, by carefully organising their time and methods and listening for lecturer cues on what work to

cover for the most marks.

The characteristics displayed by a non-academic learner are that they are not really interested in what they are doing and haphazardly approach tasks in a negative way, picking up bits of information here and there (described by Pask of his *holists* (as cited in Entwistle, 1988, pp.93, 106) as "*globetrotting*"), trying to feign an understanding (Higher Education Practice 1, 2004, p.6 (session 2)).

2.1.4 Learning styles and inventories

Messick (as cited in Haywood, 2000, p.225-226) claims that "styles are stable and persistent characteristics of the individual", whereas approaches can change, but "Ramsden argues that both styles and strategies (approaches) 'need to be seen as consistent and context dependent'". There are several ways in which learning styles can and do get classified. Wikepedia (2007) breaks them down into VARK and others. Coffield et al. (2004a), in their report reviewing learning styles, breaks them down into five families along a continuum, briefly discussed in 2.1.4.2.

2.1.4.1The VARK model

One of the more popular styles refers to a "sensory modality as a learning style dimension" (Fleming and Mills, 1992, p.137). Fleming, in Fleming and Baume (2006, p.4), gave his modalities the acronym VARK, described in more detail below.

The origins of this style date back to the 1920's, but it has gained popularity in recent times "because its principles and benefits extend to all types of learning and development, far beyond its early applications" (Chislett & Chapman, 2005, para.7). The principles are easily adaptable into learning inventories, discussed later. The "learning style is also a reflection of the type of person you are — how you perceive things and the way that you relate to the world" (Chislett & Chapman, 2005, para.16).

The term "VARK is an acronym for Visual, Aural, Read/write and Kinesthetic" (Fleming and Baume, 2006, p.2). There are several variations on this basic theme including VAK (visual, auditory and kinaesthetic, the read/write aspect being an action and thus absorbed by the kinaesthetic aspect) (Wikepedia, 2007, para.4) and "VACT (Visual-Auditory-Kinesthetic-

Tactile)" (Chapman, 1995, para.6). These stand for the four basic learning styles, or "perceptual modes", as Fleming and Mills (1992, p.137) term them. These perceptual modes are now briefly discussed.

Visual learners "remember best what they see – pictures, diagrams, flow charts, time lines, films and demonstrations" (Felder & Soloman, 2005). They may also rely on a lecturer's expressions and gestures.

Some people have "a strong preference for verbal processing" (Coffield, Moseley, Hall & Ecclestone, 2004a, p.14), whilst others cannot concentrate on verbal stimulus for very long. They would tend to prefer discussing, debating and so on.

Read/write is probably the most common mode adopted by lecturers. Learners opting for this mode would tend to prefer learning by using writing and reading type formats, which, whilst also visual, differs in the style of presentation (Fleming & Mills, 1992, p.137).

Fleming (2005) suggests that "kinaesthetic learners think in terms of actions and bodily movement". They tend to prefer action and movement type stimulation, and perceive "through an awareness of body movements" (Coffield et al., 2004a, p.178).

Tactile learners tend to make use of their hands in the process of learning such as underlining and note taking. They also perceive "through the sense of touch" (Coffield et al., 2004a, p.179).

Some students may have developed multiple styles (termed "Dual coding theory" in Tan, Parsons, Hinson, & Sardo-Brown, (2003, p.250). Others are able to adapt to a style suitable to the task at hand. Pask, (as cited in Entwistle, 1988, p.94), described such students as 'versatile'. These students are more likely to succeed in most situations because they can adapt to new situations.

Other researchers believe that the four basic VARK modes are limiting, one notable researcher being Howard Gardener, whose multiple intelligence theory model incorporates seven intelligence types (HEP 1, 2004). Most people would incorporate two or three of these types in their being (Chapman, 1995, para.22). Gardener also accepts that these seven are not necessarily the limit and has suggested three additional types with the proviso that these additional types

may incorporate other factors besides an intelligence aspect (Chapman, 1995, para.9-11), possibly making them subjective. There is also a lack of coherency in the research and findings involving cognitive styles of learning (Entwistle, 1988, p.216; Atherton, 2002a, para.1; Fleming, 2005, para.1).

2.1.4.2 Coffield et al. reports' continuum

Coffield et al. (2004a, p.i) produced a report titled 'Learning styles and pedagogy in Post-16 Learning' that, in their opinion, "critically reviews the literature on learning styles". From an original resource set of 3800 references obtained from various media sources, they used a set of predefined criteria for acceptance and rejection (Coffield et al., 2004a, pp.5-6), narrowing them down to a final listing of 71 (Coffield et al., 2004a, p.1), all listed in Appendix 1 of the report (ibid, pp.165-168). From these they chose 13 learning styles that they believed were "the most influential and potentially influential models and instruments of learning styles and their accompanying literatures with a particular focus on validity, reliability and practical application" (ibid, p.8).

The report, using a "simple way of organising the different models according to some overarching ideas" (Coffield et al., 2004a, p.10), also identified five different family groups which it presented as a continuum (Coffield et al., 2004a, p.11; Coffield et al., 2004b, p.26). These five families, each discussed separately in Coffield et al's (2004a) chapter's three to seven, are respectively: 1) constitutionally based, 2) cognitive structure, 3) stable personality type, 4) flexibly stable learning preferences and 5) learning approaches, strategies, orientations and conceptions of learning.

This report, as with many other authors and writers on learning styles, warns against categorising students into a box, or labelling them (Coffield et al., 2004a, pp.100, 102,122). It also indicates that students shouldn't label themselves (Coffield et al., 2004a, p.128), since there is no clear evidence that students cannot adapt or change their styles.

One learning style, which first influenced the Researcher, was The Index of Learning Styles (ILS) situated in Coffield et al's (2004a) fourth family, proposed by Felder and Soloman (2005) in 1987. It has four groups of opposing styles of learners. To determine the individual's preferences for the four groups either a written or internet based multiple choice type test would

be undertaken. This model has been revised and updated over the years and has been used quite extensively on science and engineering students (Felder & Brent, 2005, p.58), the Researchers main interest group.

2.1.4.3 Inventories

Closely associated with the various learning styles are inventories which have been developed to assist in the classification of learning styles. These inventories are typically multiple choice type questions often answered using Likert scales. A degree of lack of validity (in various forms), together with reliability problems, often goes along with these inventories, all of which were taken into consideration in some detail in Coffield et al. (2004a).

The tests can usually be performed over the Internet or may be completed in paper form. Some of them are free and some are run on a commercial basis. It is important to bear in mind that, once completed, one has again to be careful of labelling a person according to a particular style because none of them are absolutes. Of the learning styles mentioned only the inventories of Entwistle and Vermunt "attempt to develop a model of learning within the specific context of higher education" (Coffield et al., 2004a, p.92).

2.1.5 Learning cycles

Growing out of the various learning styles and models that have been proposed, often in association with the various inventories, some researchers have proposed models of learning cycles that people may go through in the process of their learning. Chickering and Reisser (1993, p.3) do not consider Kolb's Learning Cycle typology as "developmental", as it does not take a persons' developmental stages into account with age, but focuses instead on what students' learning preferences are at a point in time. Kolb's experiential learning cycle is mentioned briefly here in that it had an influence on the Researcher's thoughts in setting up the research study.

David A. Kolb's experiential learning cycle, seen illustrated in Figure 2.1, was influenced by the work of Kurt Lewin (Atherton, 2005d, para.1, Coffield et al., 2004a, p.63), Piaget (Koob & Funk, 2002, p.3, Coffield et al., 2004a, p.63) and Dewey (Coffield et al., 2004a, p.63). It has since influenced many educators and companies (Pickles as cited in Greenway, 2007, paras.8-9). One of the important aspects of it is the reflection, or rumination, component. This aspect

also appears in other modern theories of learning, including the SAQA OBE system of teaching and curriculum development (South African Qualifications Authority, 2000b, p.29).

Although widely accepted and followed, it does have critiques from people in many different areas (Greenway, 2007, paras.13-26). One of them is Phil Race, who "finds Kolb and other cyclical models unrealistic, prescriptive and needlessly academic" (as cited in Atherton, 2005d, para.16).
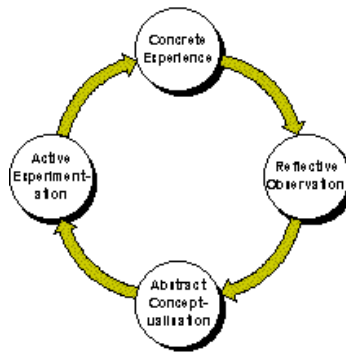
FIGURE 2.1: Kolb's Learning Cycle

Kolb (1981, pp.290-291, as cited in Coffield et al. (2004a, p.64)) indicates that it "…provides an interesting self-examination and discussion that recognises the uniqueness, complexity and variability in individual approaches to learning…", but warns against its use "…such that learning styles become stereotypes used to pigeonhole individuals and their behaviour". Coffield et al. (2004a, p. 66) also reports that one of Kolb's ideas relating to learning environments is individualised instruction and that "Kolb believes that information technology (IT) will provide the breakthrough, together with a shift in teacher's role from 'dispenser of information to coach or manager of the learning process' (1984, 202)". Kolb (as cited in Coffield et al., 2994a, p.63 and Heywood, 2000, p.239) generalises engineering students as convergers (something that the Researcher can relate to) and in a study by Buch and Bartley (as cited in Coffield et al., 2004a, p.67) on employees in a US financial institution utilising Kolb's LSI and another formulated by them, suggest that convergers prefer computers as a training delivery method, whilst divergers prefer classrooms.

If one looks at the cycle it can be seen that it is a never-ending repeating of a series of steps that one would perform in a learning situation. Heywood (2000, p.236) points out that a different learning style is required for each step and "that the cycle draws the learner into a form of

reflective practice". Thus considering the cycle, the two horizontal components represent action and reflection, also found in action research, mentioned in Chapter 3.1. This cycle was also observed by the Researcher as new information about teaching and learning were delved into. It was also hoped that this mode of action and reflection would be drawn out in the students as they went about this study and its various components described in Chapter 3.8 to 3.11.

2.1.6 Motivation

Baron (1992) and Schunk (1990) defined motivation as *"the force that energizes and directs a behaviour towards a goal"* (as cited in Tan et al., 2001, p.276). It can be roughly divided into two types, intrinsic and extrinsic. They are guided by differing requirements, the former from wanting to do something because one can, simply for self-satisfaction and the latter driven more by external forces of having to do something to further oneself in the face of other competing forces, which may also increase anxiety (Atherton, 2005c, para.1). Extrinsic motivation can arise from the attitude that one is better than someone else (Holt as cited in Rowntree, 1987, p.51). This can flow from competitive assessment, where the reward of passing an assessment derives from the knowledge that the limited number of spaces available for advancement are filled by those most deserving it (Holt, as cited in Rowntree, 1987, p.51). Feather (1982) (as cited in Tan et al., 2001, p.281) suggests a model of motivation titled "**value/expectancy theory**", whereby motivation is the "PRODUCT, not a SUM" of the two terms: value, relating to the anticipatory reward of successful task accomplishment, and expectancy being the level of successful performance associated with applying themselves. If either ingredient is missing, then motivation for the task is likely to be missing.

Motivating students to achieve in their studies is a very necessary and important part of teaching. Jerome Bruner (as cited in Tan et al., 2001, p.252) has suggested that one's "motivations to perceive" changes as one gets older, and that one can perceive from abstract situations only with age. Race P. (1999, p.3) warns teachers not to "mistake lack of confidence for lack of motivation". Practising appropriate assessment and feedback methods can be an important motivating factor, but equally as powerful a de-motivator if not handled tactfully (Rowntree, 1987, pp.200-201).

It is suggested, in Atherton (2005a, para.4) that deep and surface learning (discussed previously in Chapter 2.1.2) "correlate fairly closely with motivation: "deep" with intrinsic motivation and

"surface" with extrinsic, but they are not necessarily the same thing. Either approach can be adopted by a person with either motivation", hence again one needs to beware of labelling or categorising students. Apter (as cited in Coffield et al. 2004a, p.120) intimates that if students understand and are more in control of factors that motivate them, they are likely to be better learners.

Klug (1974) (as cited in Rowntree, 1987, p.15) proposed "thirty two reasons for formal assessment", one being student motivation. Rowntree (1987, p. 22) defines this as "using assessment…to encourage the students to learn", but points out that it can also be used by teachers to put forward what they believe is important for students to know. "Entwistle and Percy (1974) and Hounsell and Ramsden (1978)" (as cited in Ramsden, 2003, p.30) have both reported many criticisms of students lack of motivation "even at the end of their degree courses". However, it must be remembered that good teaching motivates students (Ramsden, 2003, p.113).

2.1.7 Constructivism and active learning

Atherton (2005b, para.1) describes constructivism as the educational approach that "emphasises the role of the learner in constructing his own view or model of the material" and that it is based on cognitive theory. It is sometimes used to describe a paradigm of research (Guba, 1990, p.17), but is used in this study as one of the most popular models of learning (Morphew 2002, p.1). The basis for it is that the student is actively involved, with the teacher, in the learning process of constructing meaning (Atherton, 2005e, para.1; Morphew, 2002, p.1). It has very close links with the ideas of Piaget and Vygotsky, both considering the cognitive development of the child together with their later development into adulthood. Inherent in the constructivist philosophy is the idea of reflection (Jonassen, 1994 (as cited in Murphy, 1997b, para.4); Murphy, 1997b, para.10; Von Glasersfeld, 1995 (as cited in Murphy, 1997a, para.10), also seen in the second stage of the Kolb learning cycle (Figure 2.1).

Students generate the theory for themselves, with the assistance of the teacher, generally as a facilitator. It is how students go about the task, with the teacher guiding them through their mistakes, and not the final answer that is more important (von Glasersfeld, 1987, p.15; Murphy, 1997a, para.11). Students are thus more actively engaged in the whole process and are responsible for their progress.

According to Bonwell and Eison (1991) (as cited in Oliveira, Oliveira, Neri de Souza, & Costa, 2006, p.637) active learning requires five attributes :

(i)   Students are involved in more than listening;

(ii)   Less emphasis is placed on transmitting information and more on developing students skills;

(iii) Students are involved in higher-order thinking (analysis, synthesis, evaluation);

(iv)   Students are engaged in activities (e.g., reading, discussing, writing);

(v)   Emphasis is placed on students' exploration of their own attitudes and values.

In setting up the activities for students to follow in this research project, all of the above qualities were incorporated into the design of the computer activities. Students were responsible for their own learning and pace of progress. They interacted with their group members and computers, engaging in multiple activities using high order thinking. These are discussed in greater detail in Chapter 3.10.1. They did not however meet all the requirements of a problem-based learning (PBL) approach in that the examples used were not based on open-ended real-life problems (Boud and Feletti, 1997, p.2, Woods *et al.* (1997), as cited in Heywood, 2000, p.336, Ramsden, 1992, p.148) but limited to the typical ideal process problems normally used in the subject as it currently exists. Nor were they multidisciplinary, engaging with information from other subjects or disciplines (Haywood, 2000, p.334, Boud and Feletti, 1997, p.3, Atherton, 2005f). Furthermore no "*additional information*" had to be found as suggested by Atherton (2005f).

2.1.8 Study Habits

Ramsden (2003, p.85) describes of teaching and studying "that there cannot be one 'best' way and that "it is too complicated and personal a business for a single strategy to be right for everybody and every discipline". Studying is often associated with a student's motivation, either intrinsic or extrinsic, discussed in Chapter 2.1.6, leading to a deep or surface approach, discussed in Chapter 2.1.2. Heath, Ellen and Kaira (2009) (as cited in Iqbal, Sohail, & Shahzada, 2009, p.4717) in a study of introductory psychology students concerning performance predictors found that "Motivation was the subscale that best discriminated between successful and unsuccessful students". Many studies have been done looking at the kinds of activities students use to study and they may differ depending on the subject being studied

(Felder, & Brent, 2005, p.63).

Activities that students do include reading. This includes text books, journals, magazines, etc.This is closely linked with library use, discussed in Chapter 2.2.3. How they approach their studying of the material differs. Boehler et al. (2001, pp.269) investigated several ways in their study of third year medical students: consider questions before reading or just read the text, read every word or scan the text, highlight or write out main points or use single or multiple reference sources.

Other activities include the use of lectures and note taking. Plant, Ericsson, Hill, & Asberg (2005, p.101) recommend that it is "…in the classroom where students receive instruction regarding what information and skills need to be studied and practiced for high levels of performance. Therefore, it is expected that a high level of attendance is required for optimal quality of studying". Further when students work part time or party excessively this limits the time available for quality study (i.e. undisturbed, self-regulated and focused study). How students make records of lecture material varies. Boehler et al., 2001, pp.269-270 included several methods in their study of third year medical students. These included no note taking, recording lectures, a designated note taker, utilizing handouts, redoing notes later or just before examinations.

How they study and who they study with is also dependent on their personality preferences. They might like working in groups or on their own (Boehler et al., 2001, p.270, Felder, & Brent, 2005, p.59). What type of activities students do in their study time can also affect their success. They may work on tutorial problems, either independently or with guidance, consult past papers and so on.

2.2 Delivery

There are numerous ways in which one can inform students of a subject's content. Some of the more common and popular ones will be discussed here. No matter what form delivery takes Ramsden (1992, p.63) informs us that the students will often behave in discrepant ways, responding "to the situation *they* perceive,…not necessarily…that we have defined". Becoming aware of this helps us to become better teachers.

2.2.1 Lectures

Ramsden (2003, p.147) intimates that the **c**lassroom is the most frequently used place for student and lecturer interaction, where lecturing is the most common mode utilized to pass on information and is widely practiced in tertiary institutions. It has been suggested, however, that this form of knowledge transferral is one factor contributing to continued low pass rates, poor class attendance and lack of motivation amongst students. They are often "inappropriately applied" (Ramsden, 2003, p.147), considered as "old fashioned" by some and "inappropriate in the modern learning environment" (Cox, 1994, pp.58-59) and often of little teaching/learning value (Ehrlich, 2002, p.24; Felder & Brent, 1996, p.44). Ramsden (2003, p.146) suggests that good teaching strategy in lectures needs to "discourage students from using surface approaches" and that "Encouraging deep approaches…with the subject matter is even harder". Studies in this area have also revealed that this form of teaching is affected by various factors, including class size**.**

Ramsden (1992, p.158) defines a small class as anything up to 30 students. The dynamics of a small group are quite different to that of large classes (Ramsden, 1992, p.157). Larger classes may be anything above 100 students. Although the dynamics of the classroom situation may change, the lecturer's task is still the same, to "engage in active communication between teacher and students" (Ramsden, 1992, p.167).

2.2.2 Text books

As with any subject a text book is a vital medium to students to obtain an alternative viewpoint or find further information relating to the subject. Ramsden (1992, p.63) implies that students do not just read the text books but do so for a "particular audience…in response to…requirements of their teachers". Also a student's approaches to the reading of texts can be very different. Ramsden (1992, p.41-42) describes two different approaches students may take. The first is where they consider the words and sentences without considering the meaning that they are trying to impart, trying only to remember the content, a surface approach. Others concentrate on the meaning that the author is trying to convey within the sentences, a deep approach. A further aspect is "how students organise the information", whether they fragment it or bring it all together. These approaches he describes as "*atomistic*" and "*holistic*".

There is one recommended text book for the subject, Eastop and McConkey (1993), mentioned

in the learner guide (Thurbon, 2006b, p.9), used for two follow on subjects. In addition, if students cannot afford the text book, there is a set of notes written by the Lecturer and a colleague covering the entire syllabus, which students can access in the library at any time and photostat. These two reference sources will be discussed in Chapter 4.3.2 when the sign convention adopted by each is discussed as part of the analysis of the Concept Test, detailed in Chapter 3.10.

2.2.3 Use of library

Chen (1997, p.71) defines libraries as "an enterprise...for converting quantifiable resources (inputs) into student learning and teachers' research (outputs)", but are constrained like everybody else to tight budgets and that they need to run efficiently. Erdamar and Demirel (2009, p.2234) suggest that "only very few of the students currently use the library efficiently" but that "students' efficient use of libraries supports their success at school". Barrett (2005, p.325) describes library use by undergraduates to "include: a high level of anxiety and low level of success in using libraries, more ''coping'' than information ''seeking,'' attempts to minimize research time and social effort, a reluctance to ask for help", with a "preference for the assistance of instructors over librarians".

O'Brien & Symons (2007, p.409) point out that today's students, having grown up in the digital computer era, have never been without the web and are often conversant with its operation and rely on its information content. Outsell Inc. (2000) (as cited in Drabenstott, 2003, as cited in O'Brien & Symons, 2007, p.410) describe students as wanting "instant gratification in terms of finding useful information as quickly as possible, used anything that they found, and always preferred online information over doing the legwork…fetching print-based resources". Bodi (2002, p.110) (as cited in O'Brien & Symons, 2007, pp.410-411) describes students as ""haphazard" in their research approach". However, O'Brien & Symons (2007, p.411) questions whether students are "truly "lazy" or are they, like many of us, opting for convenience in a sea of deadlines, obligations, and the hectic pace of daily life", but states that less than 5% surveyed never visited the library (ibid, p.414). In the OCLC Market Research report (as cited in Ucak, 2007, p.697), which included students, it was reported that many of them preferred the Internet to library resources.

After the merger in 2002 the libraries of the two former institutions were amalgamated and the

library on the Steve Biko Campus became the engineering and science library, thus enlarging the capacity of the Thermodynamics section quite considerably. They offer a range of services from printed books, journals and other materials to internet browsing, electronic databases and journals, and other electronic media. First year students are encouraged to do a library orientation course before lectures commence. This is designed to help students familiarise themselves with the library layout and referencing system. However it is not a compulsory course. Besides the recommended book mentioned in Chapter 2.2.2, there are additional references in their learner guide (Thurbon, 2006b, p.8), to other Thermodynamics text books available in the library.

2.2.4 Computers

There are many styles of alternative teaching methods, both formal and informal. They may embrace individual or group work (small or large). Some methods may utilize computers and those methods will be discussed in more detail here. Bourne and Brodersen (1995, p.239) envisage that engineering education will become "electronically-based", with students being able to learn anywhere at anytime, learning in "cooperative work groups", using multi-media "materials located anywhere in the world's information infrastructure".

2.2.4.1 Computers in teaching and learning

Computers have now become a vital component of any higher education institution. They control all areas and functions within these organisations and are now more available to students for a wider variety of applications than when first introduced. However, when it comes to teaching with computers, it must be remembered that they are tools to assist lecturers in coursework and not a replacement for lectures. Mehl and Sinclair (1993, p.9) point out that their early users of the computer-assisted instruction (CAI) had to show the proportions of the syllabus covered by other teaching instruction styles besides computers, to ensure a balance.

Computers are now used quite extensively in education to enhance the teaching and learning experience. They offer added functionality in that they add a dynamic visual aspect to the learning. They are fairly cost effective and available today in moderately large numbers to students in most education institutions. Scott and O'Connell (1999, p.2), in relation to thermodynamics, state that "among the publications and web sites of the several NSF Engineering Coalitions, there are only a few computer-oriented materials and no experiments"

and that whilst there are some thermodynamic "learning aids", they are typically "textbook or computer descriptions".

This style of presentation lends itself to a more flexible working environment where students can work at their own pace (Race, 1999, p.66) (within limits of time constraints). They can learn by doing, making mistakes along the way (Race, 1999, p.65), seeing their errors and being able to correct them, thus providing immediate feedback. Feedback is suggested by Hattie (1992, p.4, as sited in Atherton, 2010b) as "the most powerful single moderator that enhances achievement". Brown, Race and Smith (1995, pp.30-31) indicate that it should be given timeously and that with computers it can be immediate. Students can "however become sidetracked by all sorts of fascinating (or inappropriate!) things" (Race, 1999, p.64).

2.2.4.2 Introduction of computers into South African higher education
Computers were first introduced into the South African education system when the PLATO learning package was utilized at the University of the Western Cape (UWC) in 1980 (Mehl & Sincliar, 1993, p.4). The underlying reason behind this was for "a less rigid, less lecture-dominated, more learner-centred teaching-learning arrangement" (Mehl & Sincliar, 1993, p.5). Also, "lecturers became keenly aware of, for example, what it meant to set educational objectives ...and how important formative feedback was in facilitating the learning process" (Mehl & Sincliar, 1993, p.7). Twenty seven years later those ideas are firmly entrenched in the new SAQA OBE system, introduced in Chapter 1.2. One of the fundamental tenets of OBE is that outcomes are set to meet their objectives in a learner-centred environment, in which formative feedback is part of the system (South African Qualifications Authority, 2001, p.26).

Mehl and Sinclair (1993, p.8) discovered some important points when setting up computer laboratories at UWC, with a critical minimum of 15 to 18 terminals. Beyond a maximum of about 30 terminals control problems became an issue. Another lesson learned was that it was better to have two students per terminal than the initial three to four students.

In the 27 years that computers have been in the education arena the price of stand alone desk-top personal computers has changed little. However, their power and speed has grown tremendously. Also, users no longer need to recall many lines of very specifically syntaxed code to interact with them. Added to that is the ease with which multiple computers can be networked

so users can communicate around the globe almost instantaneously. This, however, has lead to new problems, some of which were encountered during the study and although not specifically part of the scope of this project, are discussed in Chapter 4.

2.2.4.3 Online and offline learning

Oke (2004, p.897) suggests that there is a "need for a more intense introduction of spreadsheets into the engineering education curriculum". The availability and power of modern computers means they have a role to play in education. There has been much research recently into the use of computers, often in the form of spreadsheet applications, which augment or replace the use of lecturing as the only or main means of information exchange. This method is often used in "on-line instructions and distance-learning programmes" (Oke, 2004, p.893). However, various other computer related teaching methods are currently being used such as online learning using the Internet, WebCT and others. Offline learning methods are also used, such as programming and spreadsheets.

One widely used method of teaching associated with the Internet is Web-based or distance learning, whereby there are very few if any contact periods. Students can be far away from the provider, even overseas, and still participate in the subject whilst pursuing a normal full-time job. This form of learning is flexible in that students' "study times can be varied to suit their individual requirements" (Race, 1999). Ngo & Lai (2003, pp.75-76) state that "little efforts have been devoted to develop a comprehensive Web-based courseware for Thermodynamics so far", and it was their job to do so.

"WebCT (Web Course Tools) is used to author and manage online subjects. It can be used for the purpose of distance or blended (i.e. online and face-to-face) teaching and learning." (Frank, 2006, p.16). Some lectures are replaced with a form of online classroom where students can actively participate in activities set up on an interactive WebCT page. These may include quizzes that are graded, chat rooms for both students and lecturers, notice boards and so on. It reduces the contact time between lecturer and student, forcing students to go and do research in their own time.

Another form of networked learning is e-learning. One example of this is "a game-like realistic simulation in which students had to play the role of a junior consultant" (Martens, Gulikers, &

Bastiaens, 2004, p.368) using an "authentic programme implemented in an electronic learning environment with a lot of multimedia" (Martens et al., 2004, p.371).

Offline learning is also extensively used, where here the term "offline" is used loosely to mean a non-Web-based type of learning experience. Both of the examples discussed below, programming and spreadsheets, could be, and sometimes are, associated with networked systems and the Internet since they can be used interactively with learning material on Websites (Oke, 2004, p.893).

Quite a number of engineering programmes include a subject into which a software program, such as Fortran, Basic or even C++, is introduced. Students learn to program in one of those languages, whilst at the same time learning to solve engineering type problems. These problems could be in any of the programme subjects such as strength of materials, heat transfer, electrical circuits and so on.

For engineering purposes, spreadsheets are widely used, especially where repeated or iterative calculations are required. An added advantage is that, once the equations have been set up using the powerful mathematical functions built into the spreadsheet programme, alternative solutions are quickly available by simply changing the input variables. Another aspect associated with spreadsheets is with their graphical abilities to quickly and easily produce animated graphs that change with variable inputs. They are discussed further in the next section.

2.2.4.4 Spreadsheets and learning

Spreadsheets have been around since 1979 (Brown & Gould, 1987, p.258; Oke, 2004, p.894)) and initially utilized in the financial arena. They are a "two-dimensional matrix of cells displayed on a computer screen" (Brown & Gould, 1987, p.258). They can only accept two formats in their cells, label (alpha numeric characters in strings) or values (numeric data and associated symbols, including formulas). "Spreadsheet languages differ from most other commonly used programming languages in that they provide a declarative approach to programming, characterized by a dependence-driven, direct-manipulation working model" (Rothermel et al., 2000, p.230).

Today spreadsheet programs are readily available at moderate cost. Quick to learn as they are

mostly menu driven, spreadsheet programs can reduce the tedious process of repeated calculations and, once programmed correctly, are accurate and precise. However, it has been estimated that between 20% and 40% of spreadsheets contain user-generated errors (Brown & Gould, 1987, p.259), of which a large proportion often involve cell referencing in formulas. Other research has confirmed that spreadsheets were found to contain errors between 20,8% and 60,8% of the time, and 55,8% of errors are missed when inspecting spreadsheets (Rothermel et al., 2000, p.230). Lack of pre-planning preparation, by designing the layout on paper beforehand, can increase the problems of errors in spreadsheet design, even with experienced spreadsheet designers. In Oke (2004, p.894) "Rajalingham [45] argues that the problem of spreadsheet errors has adverse real-life consequences on engineering education".

Oke (2004, p.893) describes spreadsheets as providing "a unique perspective on the relationship between the component of an equation-an understanding that is essential in engineering analysis". Quick to program, they can show the 'what if' solution to sample data, enhanced by the visual output of graphs. Bissell (as cited in Oke 2004, p.897) also pointed out that errors in graph plotting are reduced when compared to hand drawn methods. Many examples of spreadsheets utilized in various engineering fields to teach both mathematical and engineering principles abound, including "Computer animation" (Doak *et al.* (2000), as cited in Oke (2004, p.895)). Many of the studies utilizing spreadsheets have focused on heat transfer (Lawson, 2004, pp.984-990; Jordan, 2004, pp. 991-998; Schumack, 2004, pp.975-983, Hale and Grant (as cited in Oke, 2004, p.895)), which are ideally suited to this form of computational analysis. Other areas include design optimisation and analysis algorithms (Tai (1999), in Oke, 2004, p.896) and fluid dynamics (Schumack, 2004, p.981). In an electrical engineering application :

> Stanton et al. [12] used the power of PC-based spreadsheet programs to aid students' understanding and cognitive development...The work demonstrated how students could focus on gaining a conceptual understanding of signal and linear system analysis while de-emphasising the rigours of developing a user interface (as cited in Oke, 2004, p.895).

However, very few if any spreadsheet applications appear to concentrate specifically on the fundamentals of Thermodynamics, introduced later in 2.3.1.

Another use of spreadsheets has been in the generation of random multiple-choice quizzes to "engineering students in non-supervised testing environments (NTSE)" (Maurice & Day, 2004,

p.958). These are mostly performed online, partly in an effort to reduce cheating by students, but also to reduce marking errors with large numbers of students. Maurice and Day (2004, p.964) indicate that their NTSE test method is more suitable for mathematical type questions than text-based questions.

2.2.5 Dialogic teaching

Dialogic teaching is a form of verbal interaction between two or more people. The degree to which one can analyse verbal interaction is divided into three forms by Brookfield and Preskill (1999, p.4), namely "conversation, discussion and dialogue". Each of these forms is analysed differently by others. Lipmann (1991, as cited in Brookfield and Preskill (1999, p.4)) considers conversation as seeking equilibrium and dialogue as disequilibrium, generating greater debate. Burbules (1993, as cited in Brookfield and Preskill (1999, p.4)) describes conversation as less formal and dialogue as more inquiring. Bridges (1988, as cited in Brookfield and Preskill (1999, p.4)) distinguishes between discussion and conversation in the seriousness of the "development of knowledge, understanding or judgement of those taking part". Dillon (1994, as cited in Brookfield and Preskill (1999, p.4)) defines conversation as directionless whereas discussion is directed. Rorty (1979, as cited in Brookfield and Preskill (1999, p.4)) on the other hand, influenced by Oakeshott (1962, as cited in Brookfield and Preskill (1999, p.4)) both prefer to consider all three under conversation only, that being the main aim of all three forms, the main idea being to keep the conversation flowing, the interaction with others providing a learning process. No matter what form one considers the main objectives are:

> "(1) to help participant reach a more critically informed understanding about the topic or topics under consideration,
> (2) to enhance participants' self-awareness and their capacity for self-critique,
> (3) to foster an appreciation among participants for the diversity of opinion that invariably emerges when viewpoints are exchanged openly and honestly, and
> (4) to act as a catalyst to helping people take informed action in the world".

In contrast to a conversation type interaction as described above, the inquiry method of teaching as defined by Postmann and Weingartner (1971, pp.38-47) is distinguished from the former by the style it takes, whereby the "basic mode of discourse with students is questioning" (ibid, p.44). The teacher thus answers students questions with more questions hoping to "open

engaged minds to unsuspected possibilities" (ibid, p.44), in an effort to engage students into thinking more critically. The idea behind it is that diligent students should engage in the method actively. This is in contrast to a style of learning, described as Inquiry-based learning, one type of several learning types which Kirschner, Sweller and Clark (2006, p.75) describe as a "minimally guided" approach to learning, and one of several "essentially pedagogically equivalent approaches[which] include science instruction in which students are placed in inquiry learning contexts and asked to discover the fundamental and well-known principles of science by modelling the investigatory activities of professional researchers" (ibid, pp.75-76), and in which "students are expected to choose a method of solving a given problem, not merely execute a predefined series of steps" (Recktenwald and Edwards, 2010, p.2). Both inquiry-based teaching and learning have been used in science education. Kirschner, Sweller and Clark (2006, p.76), however, disagree with inquiry-based teaching amongst others (Constructivist, Discovery, PBL, Experiential), suggesting that the "past half-century of empirical research on this issue has provided overwhelming and unambiguous evidence that minimal guidance during instruction is significantly less effective and efficient than guidance specifically designed to support the cognitive processing necessary for learning". Sweller (1988, as cited in Kirschner, Sweller and Clark, 2006, p.77) describes these methods as placing "a huge burden on working memory". Hmelo-Silver, Duncan and Chinn (2007, p.99) counter that inquiry learning is a" powerful and effective" approach to learning that uses "scaffolding extensively thereby reducing the cognitive load and allowing students to learn in complex domains".

2.2.6 Group work

Group work has several advantages. It encourages participation from the group members whereby they can actively share ideas (Race, 1999, p.4), debate issues and hopefully come to a common conclusion or compromise. Studies done by Brennan and McGeevor (1988) (as cited in Ramsden, 2003, p.30) suggest that the graduates in their study would have encouraged the learning of teamwork skills whilst studying. Student's lack of cooperative learning skills is also a view expressed by lecturers (Ramsden, 2003, p.31). Group work involves listening to group members, discussing ideas, illustrating solutions, a form of "peer tutoring (Bruffee, 1995)" (as cited in Heywood, 2000, p.209), requiring activities associated with the Cognitive domain of Bloom's Taxonomy (1956) (as cited in Atherton, 2010a). Heywood (2000, p.374) indicates that team work is "a skill highly prized in the outside world". As an Engineer one has to be able to work effectively with others as part of a team. Hence cooperative activities involving groups

would nurture this skill.

Combining group work with computer-aided learning using spreadsheets, the main focus of this thesis (see Main question), adds a visual component to the learning as well. It also involves motor and auditory skills, since students were required to actively participate and co-operate in their groups to achieve solutions to the tasks given, discussed in Chapter 3.9. Students would then need to actively carry out the tasks on the computer, utilising their keyboard skills, involving activities in the Psycho-Motor domain (Dave (1975), as cited in Atherton, 2010a). Further, Heywood (2000, p.232), in relation to spatial abilities of students, suggests that computers may aid in the development of three dimensional capabilities of students. In this study a student's ability to view two dimensional pressure versus volume graphs, associated with three dimensional situations (e.g. volume of a cylinder) and how they change with each new problem, was required.

Furthermore, group work becomes a more student-centred style of learning with the teacher becoming a facilitator, guiding students when and where necessary. Ramsden (1992, p.160), however, warns about the use of computers becoming "an electronic page-turner that rewards surface approaches to learning". In this project, as students were to be active participants in the exercise, it was hoped to avoid this pitfall. Heywood (2000, p.210) warns however that the choice of groups needs to be considered as random selection "can lead to conflict and a failure to learn". The allocation of group members is dealt with in 3.8.1.

How do students learn thermodynamics? (Sub question 1)

An investigation as to how students go about learning a subject was carried out as part of this project. A study survey relating to students backgrounds and study techniques was designed and issued (see Appendix H).

2.3.1 Thermodynamics

Thermodynamics is one of the fundamental subjects studied in both the sciences and engineering. As expressed by Sprackling (1993, p.viii), reading through one's notes once is an almost sure way to failure. Beyond that is the fact that the first several sections covered in thermodynamics, and probably in most other introductory thermodynamics subjects, are very

conceptual in nature. Scott and O'Connell (2000, p.1) describe the problem of learning thermodynamics as regarding "The abstractness of these fundamental relationships and graphs requires students to have moved from concrete to abstract thinking, but this often has not occurred by the second year", which is where our students are, at their second level of the diploma, after only a six month period. This abstract introduction tends to provide great difficulty for most students. Integrated within the terminology and concepts are a few fundamental equations that are used time and again in thermodynamics. Heywood (2000, p.201) defines concepts as the "building blocks for the knowledge scaffolds of frames of reference we construct" and that they "create the structure of content (knowledge); without content there can be no learning". However, he indicates that much evidence has been gathered "that students have difficulty in learning concepts in higher education" (ibid, p.203).

From the Researcher's perspective, one of the first problems students appear to experience is with the terminology associated with thermodynamics. Closely allied with this are the rules and laws of thermodynamics that utilize this terminology. To disregard any one of the components mentioned would almost certainly lead to a failure in the subject. Each aspect mentioned will be covered in more detail below.

2.3.2 Learning the language for an engineering topic

The nomenclature of thermodynamics is almost universally consistent, no matter whether it is taught as part of an Engineering, Physics or Chemistry course. However, the same words that may be used in more than one engineering subject may have different meanings within those subjects (Jong, Couvillion, & Larry, 2002, p.3). Heat and work are both fundamentally important terms used in thermodynamics. The term heat has been inappropriately used or described in the past in many instances and may be given different descriptions in different texts (Jong et al., 2002, p.2; Loverude, Kautz, & Heron, 2002, p.147). Similarly, the term work is also described inconsistently and inappropriately (Jong et al., 2002, p.3). It is important therefore to take the time to investigate them thoroughly, and to use them appropriately in the context in which they are situated.

The Researcher has frequently witnessed the use of the words 'heat' and 'temperature' inappropriately by students. This has also been observed by Meltzer (2004b, p.34), who states it as "long recognised as a recurring learning difficulty in teaching thermodynamics to diverse

student populations". They also exchange the heat or work energies for each other almost randomly since they both have the same units. This was also observed by Loverude et al. (2002, p.142) when analysing the answers to problems posed to students.

2.3.3 Laws of thermodynamics

In classical thermodynamics there are only two laws, appropriately named the first and second laws. In modern thermodynamics a third one has been introduced, labelled the zeroth law, since it presupposes the other two. It is these laws and their associated equations that are fundamental to thermodynamics, and can cause great stress and anxiety to students. Meltzer (2004a, p.1432) indicates that only about ten studies associated with these laws, at the university level, have been published. Loverude et al. (2002, p.146), in their study of students and the first law, found that students often ignored the first law, their main analysis tool in trying to solve problems the researchers posed. Instead students try to solve the problems using the ideal gas law, something not covered in the early stages of the subject as detailed in the next section, nor required for the exercises given. This could be because they could have covered the ideal gas law in one of their school science subjects, or they may be repeat students and thus have covered it previously.

2.3.5 Other problems related to thermodynamics

In the Researcher's experience errors in the written text, many involving incorrect answers given to tutorial questions in some of the subject's text books have in the past had a detrimental impact on thermodynamics. Further, worked examples in the text have errors in them, thus making it difficult for students to follow the solution. Scott and O'Connell (2000, p.3) point out the format of presentation in a typical thermodynamics text book as "*Properties* of real and ideal gas substances come first, followed by *processes* for the First Law of Thermodynamics with applications to closed and open systems including cycles, followed by the Second Law for individual heat and work machines, and then analyses of multiple process units". The recommended text book for this subject, and others including the notes mentioned in Chapter 2.2.2, follow a similar linear form of presentation, also followed by the Researcher, but introduce the real and ideal gases after the rest of those mentioned. The implications of this are discussed in Chapter 2.4.1.

What problems do students studying thermodynamics experience and why? (Sub question 2)

An investigation into what difficulties students have during their thermodynamics studies at DUT was conducted, answered partly using the study survey and also using the interviews.

2.4.1 Conceptual problems

As discussed in Chapter 2.3.1 the introduction to Thermodynamics is very conceptual in nature. Unlike many other subjects this is often the first time that students have come across this type of content in an abstract manner as discussed in Chapter 2.3.1. It is typically taught sequentially, as are most subjects, moving on from one concept to another, as described in Chapter 2.3.5. For students who do not like learning in this style, "global learners" as defined by Felder and Silverman (1988, p.679) who prefer to see the bigger picture initially, this can cause great frustration and they may become bored or disruptive in class, or worse drop out. A further consequence of this, as pointed out by Scott and O'Connell (2000, p.3), is that one "assumes that students are not only familiar with, but

have actually considered in depth, the behavior and consequences of fluid flow, phase changes, measurement devices and materials of construction on their own or in prior schooling". Their solution to this is a "blend of alternative structures", which is more in line with the way the Researcher typically approaches the subject.

Another problem faced by many students today is their lack of exposure to equipment or industry such that they can relate the class theory to the real world. Scott and O'Connell (1999, pp.1-2) suggest that "While students in years past usually had some intimate familiarity with Natural behavior and engineered systems, teachers can no longer rely on such background to build connections between book material and engineering reality". This problem is exacerbated by the fact that many students come from poor communities with rural schools who have limited resources, where "vast numbers of black Africans remain trapped in poverty in townships and rural areas" (Letseka, & Maile, 2008, p.5). Bhorat et al. (as cited in Cosser and Letseka, c.2009, p8) found that "attending a rural school [was] found to have a significant impact on the probability of graduating".

2.4.2 Use of resources

There are various sites on Campus available to students, as detailed in Chapter 1.7.3. However,

as with most facilities they are only operational for part of the day and sometimes into the evening. In the evening there are extra problems some of which will be highlighted in Chapter 4.

How and when students use these resources and how effectively they use them is entirely up to them. If one considers the library, an important source of information, the experiences of students as mentioned in Chapter 2.2.3 is not always a good one and can be a great waste of valuable time. The Researcher has often been approached by students saying that "it isn't in the library" when he knows full well that it is, often in multiple references. They just don't know where to find it or haven't asked the subject librarian, listed in their study guide, for assistance as indicated by Barrett (2005, p.325).

The use of computers, introduced in Chapter 2.2.4, situated in the computer laboratories, described in Chapter 3.7, played a major role in this study as highlighted in Chapter 3.3. Hence, computer operation and the use of spreadsheets as described in Chapter 3.8 were pivotal for the success of this study.

2.4.3 Mismatch of preferred learning style and delivery

Atherton (2008) argues that there are so many styles, most of which, typically, would be present in any one class of students that it is almost impossible to cater to all needs at one time. Indeed "pandering to learning styles may be doing the students a disservice: they will benefit more from adapting and becoming versatile, more able to respond both to formal teaching and learning from experience". Because of the variations in styles and the potential for mismatching them, Fleming (2005, para.18) suggests that it may be "more effective to think in terms of accommodating, rather than matching, modalities ["a combination of perception and memory" (Fleming, 2005, para.10)] and styles".

Felder and Silverman (1988, p.679) indicate that most subject material is presented in a "logically ordered progression", also mentioned in Chapter 2.4.1. This method, typically used throughout school and into tertiary education, favours students who prefer to learn "*sequentially*" (ibid, 1988, p.679), which puts the "*global*" (ibid, 1988, p.679) students at risk.

2.4.4 Mismatch of preferred learning style and lecturers delivery style

Different learning styles of students have been covered in some detail in Chapter 2.1.4 and 2.1.5. As introduced in Chapter 1.5, the Researcher has over the years moved his presentation style to one that is similar to "the inquiry method" (Postman & Weingartner, 1971, pp.38- 47), which is typified by the teacher answering a student's question with another question, as detailed in Chapter 2.2.5. As most students don't ask questions in the first place this can have a negative impact since students may become reticent in asking questions. The idea behind it was to draw out the student's thinking at the time to try to get a feel for their understanding of that section.

Felder and Silverman (1988, p.680) argue that most engineering student learning style are "visual, sensing, inductive, and active", with a few global students, whereas most engineering presentation by lecturers is "auditory, abstract (intuitive), deductive, passive, and sequential". This creates a division between presenter and receiver. It can however be overcome by creative means such as changing presentation styles, incorporating exercises to stimulate thinking, showing relationships to other subjects and so on.

Did the intervention improve pass rates? (Sub question 3)

Assessment of students in various forms and styles is used as a measure of their knowledge and understanding of a subject. These are typically in the form as described in Chapter 1.4. However, alternative methods of assessment are available and were used in this study and will be discussed below. To determine what difference the intervention made, if any, a comparison of marks within the study semester (test 1 and test 2 marks, semester 2, 2006) was carried out. A comparison of marks for a control group, comprising the combined results from the previous five semesters (test 1 and test 2 marks) was also carried out. Then the intervention semesters marks were compared with the control groups marks to see what difference, if any, the intervention made to student pass rates

2.5 Assessment

The assessment of students and how to grade them is a much debated issue. Boud (1995, p.35) describes assessment as one of the worst areas for "bad practice and ignorance" in higher education, but to be able to quantify the level of understanding reached by students, some form

of assessment needs to be done. The "MacFarlane Report (1992)" states that "assessment is the single most influential factor on student learning" (Falchikov, 1995, p.160). However, several important items need to be considered before the assessment takes place, including whether to assess the outcome or the method of achieving it.

SAQA (2001, pp.16-19) guidelines for a credible assessment are that they should be fair, valid, reliable and practical. This is because they typically "affect personal, social and economic progression and mobility in society". They should thus "provide accurate information about the individual". To gain a better understanding of a students' abilities SAQA (2001, p.51) recommends that more than one assessment method be used. There are a number of assessment methods recommended by SAQA together with a variety of assessment instruments to choose from (SAQA, 2001, p.26). Ramsden (2003, p.184) poses two important points about choosing a method. Firstly it is not the method that determines the learning but how students relate to them and secondly that no one method will suffice.

One of the most important components of assessment is feedback to students of assessments (Ramsden, 1992, p.99). Huba and Freed (2000, p.153) indicate that not only do students need feedback but they also need to learn how to use it.

2.5.1.1 Assessment of group work

One of SAQA's eight critical cross-field outcomes is to be able to work with others as a group (SAQA, 2001, p.24). It further suggests that to encourage learners to reflect on their learning, peer assessment of group activities could be undertaken (SAQA, 2001, p.36). Setting and assessing group work can benefit student development since they have to work collaboratively. They can usually achieve more as a group than individually and there is less marking to be done (Brown, Race and Rust (1995, p.83).

Brown, Race and Smith, (1995, p.26) suggest getting students involved in assessing as a learning task. When assessing work done by students this can be done by assessing the process or by assessing the product (ibid, 1996, p.18). In this study only the product was assessed by students. However aspects of how they constructed the spreadsheets would come into the assessment since students would have to interact with their peer's spreadsheet to perform a task. They further suggest that "assessment methods can be designed to maximise student

motivation" and that students will only put effort into work that is rewarded (ibid, 1996, p.17). They also stipulate that assessment criteria be clear (ibid, 1996, p.60).

The assessment methods used in the Thermodynamics II subject have been described in Chapter 1.4. Even though these methods have been used for many years, educationists must always be open to the possibility that the assessment methods do not match with the learning programme. So for this research project, some new tools of assessment for this subject were devised and utilised, namely peer assessment (discussed in the next section) and the concept test (quiz), described in Chapter 3.10.

2.5.1.2 Peer assessment

The practice of assessing one's peers as part of the overall assessment of any particular component of a subject is becoming more popular and acceptable, helping to create more awareness by students of the process involved and to "take ownership of their learning" (Beylefeld, Joubert, Jama & de Klerk, 2003, p.6). At Manchester Metropolitan University (as cited in Haywood, 2000, p.378), although students were of the opinion that assessment was a tutors job, they realised that it was motivating as they felt a part of the process. For formative assessments peer assessment can take the form of two different types, intra-peer group, whereby students assess the performance of their group members or inter-peer, whereby students assess the products of other groups (Brown, Race and Rust (1995, p.83). In this study the latter was to be evaluated, whereby each group was to assess one other group's computer spreadsheet. Student feedback of peer assessment indicates that they see it as useful, in that it provides enlightenment into how the other students go about their work, and the fact that there are multiple markers is seen as fairer by the students themselves (Falchikov, 1995, p.160).

Mindham (1998, p.50) mentions that "students facing peer assessment for the first time will feel uncomfortable, inadequate or inexperienced". Another problem associated with peer assessment has been unwillingness to award a mark and also of failing a peer (Falchikov, 1995, p.160). Heywood (2000, p.376) argues of the reliability of summative peer assessment in the early stages of a student's career and that formative peer assessment "should be regarded as training for later…years". It thus needs to be guided carefully such that all students are aware of the processes and they are assessing each other in a consistent way. This process can be assisted by using a rubric, the details being discussed in Chapter 3.8.3.

Summary

This then sets the scene for the intervention. Learning as applied to students can take on many forms and variations, which can change with the context of the situation in which it is being presented. Delivery, and the context in which it is delivered, can also affect the learning and its style. Computers have placed another tool into the teachers' arsenal, but as with all new systems, can have unpredictable effects. Within this framework, and using computers as an aid to the teaching and learning process, a computer assisted intervention comprising several tasks was formulated and is described in Chapter 3, together with the paradigms in which they sit.

CHAPTER 3

RESEARCH PARADIGMS AND HOW THE STUDY WAS SET UP

3 Overview

This chapter is broken into two parts. First the study style, paradigms and structure is considered. Here it defines the style of study, a case study, then considers the paradigms in which this thesis was situated. Then the Research procedures are explained and how they fit into the Research paradigms in comparison to the normal semester program, followed by scope, limitations and exclusions from the study. It compares the intervention mark allocation to a typical semester and then considers the assessment procedures that were used for the intervention. Finally the computer laboratories available for the study are introduced.

The send part of the chapter, the interventions, then explains the details of each intervention of the study in turn and how they were orchestrated.

The Study Style, Paradigms and Structure

3.1 A Case Study

Punch (2005, p.144) considers the case study as "more a strategy than a method", as does Denscombe (2003, p.32). Punch (2005, p.145) defines four characteristics for case studies; "…a 'bounded system'…, …is a case of something…, …'holistic'…specific focus is required…, …multiple sources of data and multiple data collection methods are likely to be used…". Guba and Lincoln (1981, p.372) (as cited in Jarvis 1999, p.78) mentions four reasons for doing case studies, namely "Chronicling…, Rendering…, Teaching…, Testing…". Merriam (1988, pp.11-12) (as cited in Jarvis (1999, p.78) proposes four reasons for considering case studies "Particularistic…, Descriptive…, Heuristic…, Inductive…". Case studies typically involve multiple sources of evidence (Yin, 1984, p.23, as cited in Punch 2005, p.145, Denscombe, 2003, p.31, Gillham, 2000, p.2).

Stake (1994) (in Jarvis 1999, p.76) intimate that cases typically involve people and situations but not processes since they lack "boundedness". Jarvis (1999, p.76) disagrees since it is nearly impossible to separate the teaching research from the process and he goes on to suggest that the

Researchers own identity be included in this since he is part of the process. Punch (2005, p.144) also includes a process "since almost anything can serve as a case… But, with Miles and Huberman (1994), we can define a case as a phenomenon of some sort occurring in a bounded context". Yin (2009, p.17) also includes "processes", as well as "programs" and "events". A case study typically consists of one instance (Denscombe, 2003, p.301, Gillham, 2000, p.1) although it may consist of multiple cases (Gillham, 2000, p.1, Yin, 2009, p.19). In this sense research into one's practice typically considers one case.

Yin (2009, p.18), describing the case study as "an all-encompassing method", defines a case study as:

"an empirical enquiry that

- o Investigates a contemporary phenomenon in depth and with-in its real life context, especially when
- o The boundaries between phenomenon and context are not clearly evident".

He goes further by saying that "case study enquiry

- o copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result
- o relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result
- o benefits from prior development of theoretical propositions to guide data collection and analysis."

Stake (1994) (in Punch, 2005, p.144) distinguishes between three types of cases, intrinsic, instrumental and collective. The first two involve a single instance, whereas the third involves a number of cases or comparisons. Yin (2009, p.8) defines three types of case study, namely exploratory, descriptive and explanatory, but emphasises that the boundary between each type is not distinct. In choosing a research method he recommends that three important conditions need to be considered, the "*Types of research questions*", the "*Extent of control over behavioural events*" and the "*degree of focus on contemporary as opposed to historical events*". Within these bounds the Researcher would consider either an experimental method or a case study. However, the experimental study claims a degree of control over behaviour. Whilst the Researcher had control over the environment (the computer laboratory) he had very little control over what the students did in the laboratory. This then favours the case study approach.

There are also criticisms of case studies. Firstly, many case studies are inductive in that the outcomes may be specific to that case rendering generalizations impossible (Gillham, 2000, p.6, Merriam, 1998, pp.11-12, as cited in Jarvis, 1999, p.79, Denscombe, 2003, p.36, Punch, 2005, p.145, Yin, 2009, p.15). However, as Punch (2005, pp.145-147) points out, it depends on the type of case being studied as to whether it can, or indeed needs to be generalizable. If generalization is sought then data analysis needs "to be conducted at a suitable level of abstraction".

Secondly, case study research has often been considered as "soft" (Gillham, 2000, p.10, Denscombe, 2003, p.39, Yin, 2009, p.21) as it lacks the rigor of other types of social science research, partly because of their qualitative nature but also because the rigors of the approach may not have been met.

Jarvis (1999, p.89) suggests that the practitioner researcher is investigating their own practice and that they are an active participant in the process. As such he suggests that this is a form of Action Research. Action Research is typically undertaken to bring about change in the participants (Jarvis 1999, p. 91, Stringer, 1999, p.11), or it may be "devised specifically as experiments" (Jarvis 1999, p.80), both of which this study could fall into, although it was not designed as an Action Research study.

A case study was thus chosen as it was a bounded instance, the Thermodynamics II class for Semester 2, 2006. The main emphasis was on the computer interactive laboratory sessions. Multiple sources of data collection and type were used, discussed later in this chapter. This suggests a mixed methods study (Yin, 2009, p.62). A case study is also often a once off intervention, done as a trial to investigate in this instance: firstly, if the style of delivery, in this case using computers as discussed in Chapter 2.2.4, affected student learning and influenced the pass rates and secondly, to investigate how students learn thermodynamics. It also shares many of the characteristics of Action Research, but was not implemented as such.

3.2 The paradigms, A theoretical framework
In order to find a framework within which to work one needs first to discover ones' starting point. In engineering one tends to be taught by engineers who typically reside in a positivist

paradigm, often without even realising it. Hence, to get a feel for where one is situated, it is first necessary to describe the activities involved in this thesis, at the same time situating them in the paradigm in which they belong.

In order to undertake this study it was necessary to step out of the comfort zone of a clinically distant positivist paradigm (Cohen, Manion, & Morrison, 2000, p.19), and step into one in which students could be active participants. Since there were both quantitative and qualitative components to the analysis of the data, this necessitated a multi-paradigm approach. The dominant paradigms of modern social science research are the interpretive paradigm (Cohen et al., 2000, pp.22-23; Neuman, 2000, pp.70-75) and the critical paradigm (Cohen et al., 2000, p.28; Neuman, 2000, pp.75-81). The former is the preferred one here, as the idea behind this study was not that society or its participants were necessarily flawed, or needed changing (Cohen et al., 2000, p.28).

3.2.1 The Positivist Paradigm

Neuman (2000, p.66) defines positivism as "an *organised method for combining deductive logic with precise empirical observations of individual behaviour in order to discover and confirm a set of probabilistic causal laws that can be used to predict general patterns of human activity*". Within this paradigm the epistemological stance of the researcher is seen as being an external neutral observer i.e. external to the experiment with no influence on the situation under observation. As Guba (1990, p.20) implies, the "Values and other biasing and confounding factors are…automatically excluded from influencing the outcomes". This can become difficult, however, when other human beings with different ideals, values and beliefs become involved in the process.

As mentioned previously in Chapter 1.4, most engineers are taught, predominantly by other engineers, who operate within the positivist paradigm, and thus tend to remain in this paradigm throughout their lives. Neuman (2000, p.65), in reference to positivism, points out that "most people never hear of alternative approaches". Like many other staff members, before embarking on this study, the Researcher was unaware that he too was labelled a positivist. This was borne out in a survey, originally used by Luckett (1995, pp.9-10) at a SAAAD conference on Curriculum Development. It was posed at random to staff and students in the Mechanical Engineering Department at DUT in 2005. The majority of responses indicated that both staff

and students operated within this paradigm and yet were unaware of the term.

This then is typically the paradigm in which students and lecturers spend most of their life in engineering. The interests of the learner are not the most important, but the utilization of reliable and valid data is. Thus the syllabus is seen as the primary focus. Teaching in this paradigm is not always in the best interests of the students as it can encourage a surface learning approach (Luckett, 1995, p.32).

Comparing the results of the students in the Research study with the results from previous semesters is quantitative and hence falls within this paradigm. The Researcher can claim that the results are reliable in that they involve solving similar problems with unique answers (Heywood 2000, p.21) in all the tests and examinations and if repeated should obtain similar results (SAQA, 2001, p.18, Yin, 2009, pp.40,45). As all the tests and examinations were set and marked by him this provided a measure of consistency in mark allocation and judgement (SAQA, 2001, p.18). However, one can question the validity of the data, depending on the degree of validity required. If one compares the learning outcomes (Appendix W) with the questions posed in tests and examinations then one could state that face validity and content validity (Heywood 2000, p.21) have been met. The questions posed cover many of the learner outcome requirements (for example, '*use the non-flow and steady-flow energy equations in the appropriate applications*', which was also required of the computer spreadsheet exercises), but the degree to which it has been met may be uncertain. However, predictive validity (Heywood 2000, p.21), the ability to predict future performance cannot be guaranteed since there is no certainty that students, using the basic skills learnt, would be able to show mastery of the subject's outcomes in future assessments of a similar nature. Construct validity, "the extent to which an assessment measures the content (aptitude, attitude, skill) it intends to assess, and predicts results on other measures of content..." (Heywood 2000, p.22), is applicable to the semester tests and also the spreadsheets exercises as they both require certain skills levels to be achieved. Heywood (2000, p. 22) discusses the use of 'A' level grades as an "indicator of potential" for students entering universities in the UK to be able "to cope with university studies", but which show little correlation to the "final degree grade". Similarly in South Africa, the entrance requirements to the DIT are based on a student's final senior certificate marks (DIT, 2006a, p.6), but studies in the past have also shown little correlation of success, or final grade, in the programme.

A student study survey, the details of which are discussed in Chapter 3.9, was undertaken, to determine if any factor(s) may contribute to success. The survey, because of the style of presentation, limited the amount of interpretation students could give to their answers. Hence the analysis of this was mostly statistical, a positivist paradigm trait. It was assumed that the students gave honest answers about what they normally did, and not what they thought the Researcher would like to hear. However, there was also an interpretive paradigm aspect to the survey since there was an open-ended question at the end, where students could add anything further even if it was unrelated to the questionnaire.

3.2.2 The Interpretivist Paradigm

Neuman (2000, p. 70) describes several types of interpretive social science, namely "hermeneutics, constructivism, ethnomethodology, cognitive, idealist, phenomenological, subjectivist, and qualitative sociology". He indicates that the aim is to grasp the social interactions of people in their normal environment, by studying "*meaningful social action*". It is also usually very contextual as it typically relates to a certain situation in which it deals with the values, norms and culture associated with people within that social setting. The role of the researcher would not be an external neutral observer, as in the positivist paradigm, but would be a participant in the social interaction taking place, which could have an influence on the process.

Since the students have agency (i.e. some control over their destiny), with varying ideas of the world around them they would be likely to tackle the assignments in different ways. From an active learning perspective, using a constructivist approach as described in Chapter 2.3.5, how they would interact with their environment, the computer laboratories and other students in the class, was up to them. They were free to use the time to do whatever they wished in whatever manner they decided. This was possible operating within an interpretivist paradigm, the research paradigm investigating the teaching, since one was not trying to control the situation or the environment. The lecturer's role was simply to be a facilitator and adviser when requested. One might assume that a linear relationship between cause (the computer intervention) and effect (improved pass rate) existed. However, there could be other factors that contribute to or influence the success or otherwise of the intervention, making a simple linear assumption problematic. Other teaching methods, some of them mentioned in Chapter 2.2, could have been used besides the computer intervention that may equally have had an influence on pass rates, either positively or otherwise.

Yin (2009, p.40) states that "four tests are common to all social science methods", those being construct, internal and external validity together with reliability. For construct validity one needs to collect data from "*multiple sources*" to "establish a *chain of evidence*". Also one needs to have a "draft case…reviewed by key informants" (ibid, p.42). Internal validity was not applicable in this instance since the study was not "explanatory or causal" (ibid, p. 40). External validity applies to how generalizable a study's findings may be, single case studies often being a "poor basis for generalizing" (ibid, p.43). In this study construct validity could be claimed since multiple sources and types of data were gathered, as described in Chapter 3.2.4. Finally reliability refers to the ability to repeat the study and achieve a similar result. Considering the qualitative data collected, neither external validity nor reliability could be claimed since the data was unique to this study and opinions gathered would not necessarily apply to another class if the study was repeated.

As opposed to the positivist notion of determining the data as reliable and valid, "Lincoln and Guba (1985) suggest a different set of criteria for establishing rigour in interpretive enquiry", these being credibility, transferability, and dependability and confirmability (as cited in Stringer, 1999, p.176-177). Credibility arises from "*prolonged engagement* with participants; *triangulation* …from multiple data sources; *member checking*…check and verify the accuracy of the information recorded; and *peer debriefing*…articulate and reflect on research procedures…". Transferability is seen as being able to apply the "findings to other contexts". Dependability and confirmability are gained by the rigour in which the data collection and analysis are described and by the ability to refer back to raw data.

3.2.3 The research activities compared under the research paradigms

As described later in this chapter, various activities were undertaken in order to collect data for this study. The scope and limitations of this project will also be described later in Chapter 3.4. Part of the thinking involved was to enable students to build up the subject theory themselves, thus generating their own knowledge base, augmented by lectures. The teaching would fall in line with a constructivist style of learning, as discussed in Chapter 2.3.5, the students constructing meaning of new material for themselves in the computer laboratories, assisted by the Researcher.

In an attempt to place some clarity on the various dynamics of the research, Table 3.1 below has been included, placing the research questions and study components into perspective within their respective paradigms. The details of each component are discussed later in this chapter.

TABLE 3.1: Comparison of Research Questions, Paradigms and Research Methods

RESEARCH QUESTIONS	INTERPRETIVE	POSITIVIST
Primary: How does delivery affect student understanding?	Spreadsheet Exercises Interviews	Spreadsheet Exercises Also Test 1 vs 2 marks
Secondary 1: How do students learn thermodynamics?	Spreadsheet Exercises Study Habit Survey Interviews	Study Habit Survey Concept Test
Secondary 2: What problems do students studying thermodynamics experience and why?	Interviews Concept Test	Study Habit Survey Concept Test
Secondary 3: Did the intervention improve pass rates?		Other Semester Test and Examination Comparison with Intervention Semester Results (Tests 1 and 2, plus examination)

To add further clarity to the project, a summary of all activities in which students participated is included in Table 3.2, showing in which paradigm the analysis of those activities falls. Some of the analyses would move across the paradigms, since there are aspects of both qualitative and quantitative analysis in some of the activities.

TABLE 3.2: Comparison of Student Activities and Paradigm Analysis

STUDENT ACTIVITIES	INTERPRETIVE	POSITIVIST
Spreadsheet 1	Y	Y
Marking of Spreadsheet 1	Y	Y
Study Habit Survey	Y	Y
Spreadsheet 2	Y	Y
Marking of Spreadsheet 2	Y	Y
Concept Test		Y
Test 1		Y
Test 2		Y
Interviews	Y	
Semester examination		Y

3.2.4 Triangulation

Neuman (2000, p.125) defines "*triangulation of method*" as "mixing qualitative and quantitative styles of research and data". As several different sources and styles of data were available it was hoped to get further "credibility" by "triangulation" of the data (Locke, Silverman and Spirduso, 1998, p.100; Leedy, 1997, p.169; Denscombe, 2005, p.38). Although triangulation of methods is possible here, it was realised that the informants of this approach are from the same source, the students themselves. This may limit the generalizability (Denscombe, 2005, p39; Yin, 2009, p.43) but the sample, for most sources of data, was reasonably large, as highlighted in Table 4.2. The number of interviews conducted provided a smaller sample because of the time constraints involved in performing this task (Gillham, 2000, p.61), as well as the transcribing mentioned in Chapter 3.11.3. Nevertheless, a fairly wide spectrum of students was to be chosen for the interviews, as described by the sampling strategy in 3.11.1.

In an attempt to quantify and, to a certain extent, generalise the quantitative data further, statistical methods were employed to analyse and compare data of past and current semester tests, the methodology discussed later in Chapter 3.6 and the analysis thereof in Chapter 4.5.4. In this way the triangulation was extended to a wider population in an attempt to make the data

more reliable and externally valid.

3.3 The research procedures

Although the intervention was computer-based, in this instance it was not a web-based or distance learning internet experience of an online nature, as discussed in Chapter 2.2.4.3. It was a simple straightforward application, in which students had to use the basic methods and theory of thermodynamics, introduced in lectures, to formulate their own solutions to problems using spreadsheets.

Computer laboratory sessions, run in the laboratories discussed in Chapter 3.7, replaced about half of the normal lectures, as seen in Table 3.3 below, thus requiring students to actively participate in the learning process themselves. The stand-alone spreadsheets were developed from scratch. Using these, students could generate solutions to their normal tutorials, and other similar problems on the computer, and compare their answers to those done manually.

TABLE 3.3: Comparison of periods per week breakdown for the study semester and a typical (normal) semester

ACTIVITY	STUDY SEMESTER FORMAT (PER WEEK)	TYPICAL SEMESTER FORMAT (PER WEEK)	COMMENTS
Conventional lectures (in a class room)	2 (2 single periods)	4 (normally 1 double and 2 singles)	following a formal lecture format
Tutorials Computer laboratories	1 2 (triple period)	1	no computer sessions in a typical semester
Laboratory practicals	1	1	on average, but not part of the study

From the above it can be seen that the conventional lecture time was halved and direct student activity time was increased threefold (3/5 as opposed to 1/5), placing far more focus on active student participation, as seen in the first column in Table 3.3. As computer laboratory time was

limited to the first eight weeks of the semester, the nature of the tasks was also limited. Certain parts of the theory, which form the backbone of almost all Thermodynamic analyses, were chosen for this project. These were the six Thermodynamic processes, together with the non-flow and steady-flow energy equations, utilized throughout this subject and any associated follow on subjects.

The remainder of the semester, about seven weeks, was taken up with normal class lectures interspersed with regular tutorial periods, as seen in the second column in Table 3.3. These lectures are usually conducted by a fellow colleague and for continuity and comparison purposes this trend was maintained.

In the light of the changing field of the South African education scene, intimated in Chapter 1.2, the project was initiated in order to incorporate some of the aspects of the SAQA outcomes based education system, namely aspects of the first six and last critical cross-field outcomes (CCFO's) (South African Qualifications Authority, 2001, p.24). Aspects of computer skills learnt in the introductory computer subject (Durban Institute of Technology, 2006a, p.15), namely spreadsheets, were also brought into the thermodynamics subject. This type of knowledge would be termed "embedded knowledge", mentioned in the student's Learner Guides under that title (Thurbon, 2006b, pp.2-3), since students already possessed that knowledge and had demonstrated an ability to use it by passing the subject.

The students had to organise themselves in their teams, as discussed in Chapter 3.8.1, investigate the theory needed for the assignment, generate a working interactive spreadsheet and co-operate with their team members, other class members and computer assistants during the computer laboratory sessions. They also had to actively participate, together with their team members, in responsibly evaluating another team's spreadsheets for both computer assignments. The details of these activities are discussed in Chapter 3.8.3.

A positivist paradigm would try to minimise the influence of factors that may bias the results, but no such measures were taken. Attendance registers were taken as standard practice, and analysed in Chapter 4.1.3, the interpretation of which would reflect a positivist approach. Thus, although the study would fall within the interpretive paradigm, the influences of a positivist outlook were clearly evident.

A further aspect of the study was the interviews, "one of the main data collection tools in qualitative research" (Punch, 2005, p.168). A semi-structured interview approach was taken, the details of which are dealt with in Chapter 3.11.2, using a standard bank of questions (Appendix I). The data gained from them was purely qualitative, thus falling within an interpretivist paradigm.

3.4 The scope, limitation and exclusions

As mentioned in Chapter 3.3, the bulk of this intervention utilized the classroom component of the term time leading up to test 1. The only part not completed during the first term were the interviews, conducted some two months later after lectures were complete. This was done in order that the two teaching methods employed during the semester could be compared during the interviews: the computer laboratory intervention, where an active learning style was emphasised, described in 2.3.5, and formal classroom lectures, where a more passive learning style (Ramsden, 2003, p.108), mentioned in Chapter 2.1, prevailed.

From test 1 onwards, the delivery of the subject reverted to a conventional format, with typical "chalk and talk" lectures, carried out by the Researcher's colleague, as was done in previous semesters. Although test 2 did not form part of the study directly, the marks obtained for test 2 were compared to test 1 marks, mentioned in Chapter 3.6.

The laboratory practicals, as seen in Table 3.3, were not investigated. This decision was taken in order to limit the scope of the study, and also not to place the extra burden of investigating practicals onto students. However, as will be seen in Chapter 4, the marks for the practicals are included for comparison purposes, since there was some referral to them, mainly as opinions, in the interviews.

3.5 The intervention mark allocations

Earl (1986, as cited in Heywood, 2000, p.375-376) in a mathematics modelling subject had 10% of the mark allocated by peers, as did Butcher, Stefani and Tariq (1995, as cited in Heywood, 2000, p.377) using a combined peer assessment method of biosciences students. In Chapter 1, Table 1.1, the mark allocation for each assessment in a normal semester was introduced. In order to allocate some marks to the computer assignments, the 40% mark allocation, normally allocated to test 2, was reassigned in the intervention semester to the test 1 position, the extra

10% being allocated to the computer assignments and expounded upon further in Chapter 3.8.3. This is seen in Table 3.4 below (**the intervention marks being bolded**), the remainder of the marks (greyed out) being the same as a normal semester. This, and the implications thereof, is discussed further in Chapter 4.5.3.

TABLE 3.4: Breakdown of all mark allocations given to the various assessments

Assessment	Thermodynamics II -research semester	Thermodynamics II -normal semester
Spreadsheet exercise 1 (incorporated in Test 1 mark)	**5**	-
Spreadsheet exercise 2 (incorporated in Test 1 mark)	**5**	-
Study habit survey	0	-
Concept test	0	-
Interviews	0	-
Test 1	**40**	30
Test 2	30	40
Practical	30	30
SEMESTER MARK	100 x 0,4 = 40%	100 x 0,4 = 40%
EXAM	100 x 0,6 = 60%	100 x 0,6 = 60%
FINAL MARK	100%	100%

3.6 Assessment of the students

The assessment methods as normally used in Thermodynamics II have been described in Chapter 1.4. With this in mind several alternative methods of assessment and instruments for measuring them were investigated. The methods included all three methods suggested by SAQA (2001, p.26), namely observation, product evaluation and oral and written questioning. The instruments used were assignments, tests and examinations, personal interviews and practical exercises, as recommended in SAQA (2001, p.26). Some of the instruments were used for generating marks, specifically the assignments, tests, examinations and practical exercises, whereas interviews were used to gather qualitative data on students learning. Since various types of exercises were utilized, various styles of analysis were employed to analyse the data generated. Hence both quantitative and qualitative analyses were used, within their respective paradigms, as discussed in Chapter 3.2, with the analysis thereof in Chapter 4.

The assignments, one of the main focuses of this thesis, were the computer related spreadsheet exercises that were introduced into the subject as a way promoting an active learning environment, discussed previously in Chapter 2.1.7. The tests and examinations, both summative (Heywood, 2000, p.29; SAQA, 2001, p.26), were already standard practice for most subjects taken at the University and were not altered in any way for the study except by way of test mark allocation, discussed in Chapter 3.5. They were used as a measure of a student's understanding of the subject. Thus the main focus of theory relating to assessment, test 1, was that associated with the computer assignments. The assignment assessment took the form of peer assessment, introduced in Chapter 2.5.1.2, since students were to assess the spreadsheets designed by their peers. Further details are discussed in Chapter 3.8.3.

The marks analysed in Chapter 4.5 came from the class tests and end of semester examination. A dependent T-test, was be carried out, detailed in Chapter 4.5.2, to compare the test 1 and test 2 results. Because the knowledge gained by the students during the intervention was tested in the usual way, a direct comparison could also be made between previous semester marks and the intervention semester marks. All the data for the current semester was therefore compared with the previous five semesters, as a control group, and analysed in Chapter 4.5.4 using SPSS.

Each component of the study habit survey, discussed in Chapter 3.9, was analysed separately in an attempt to explore students' approaches to their studying and performance in the subject. However, the study was limited only to the classroom aspects of the subject and no attempt was made to include the laboratory practicals, as highlighted in Chapter 3.4, or analyse them as part of this study, other than to gain some opinions from the students interviewed as to their thoughts on those practicals, discussed in Chapter 4.4.3.1.1.

The concept test, detailed in Chapter 3.10, was not assessed by anyone in any way as it was self evaluating, the final score obtained for each section being available to the student immediately after the test was completed. This gave them immediate feedback. However, the students' scores of the test were later analysed and discussed in Chapter 4.3.

As the interviews were not for marks no assessment was required.

3.7 The computer laboratories

There are several computer laboratories available on the Steve Biko Campus, the Engineering, Science and the Built Environment (ESBE) Campus. These are detailed in Table 3.5 below, together with notes on their uses and any limiting factors.

Table 3.5: Computer Laboratory Facilities on the Steve Biko Campus

ROOM	PC's	CONTACT	NOTES
S9-001	40	Clement 2818 clementz@dit.ac.za	Stand alone computers (with own hard drive), all net linked. Essentially open access after 16h30, but closed access and bookable for lecturing during the day. Reserved for ESBE students, when not booked during the day, and open to all students at night.
S9-006	40	ditto	ditto
S9-011	50	ditto	½ stand alone (with own hard drive) and ½ network (no hard drive) computers, but all net linked. Essentially open access after 16h30, but closed access and bookable for lecturing during the day. Reserved for ESBE students, when not booked during day, and open access to all students at night and weekends.
S3-1	45	Lucky 2129 luckyd@dit.ac.za	Permanent open access with no booking. Only ESBE students can utilize.
S3-2	40 +13 new expect-ed	ditto	Only Mechanical and Chemical Engineering students can utilize. Pre-book (day before) in one of 3 sessions (08h30-11h00; 11h15-13h45; 14h00-16h30). Can be used for class sessions.
S3-3	40	ditto	Only BTech (Mechanical and Chemical Engineering) and Autocad students can utilize.

The original laboratory chosen was in S3-2. Only available to Mechanical and Chemical

Engineering students on a pre-booked basis, it housed 40 computers with 13 new arrivals expected in the term of the intervention. It was thus fairly controllable access wise, located close to the Mechanical Engineering Department, large enough to accommodate the class in a single venue and transparent via the Ethernet to the Researcher's computer to access it outside of contact time. However, shortly before the project was to start it was broken into, some of the computers removed and the ones not removed were vandalised beyond use. The only alternative laboratory was S9-001, with spill over into S9-006. These two laboratories, although in the same building, were located at a distance to the Mechanical Engineering Department, large enough to accommodate the class but in two venues and, for some unknown reason, not transparent via the Ethernet to the Researcher's computer to access it outside of contact time. Backing up thus had to be done at the venue's controlling computers, housed within the S9-011 room located adjacent to the two rooms used.

These two laboratories were then booked for each session for the exclusive use of this class. There were thus plenty of terminals and space available. However, it was permanently hooked to the internet which caused several problems, discussed in Chapter 4.1.1.1. It was also located next door to the general open access laboratory, open to any ESBE students all the time, which caused further problems.

The Interventions

This study explored the theories of teaching and learning, discussed in Chapter 2.1 and 2.2, specifically in relation to using computer spreadsheets as a tool in an engineering discipline and explored the problems experienced along the way. In Chapter 4, the data generated from the interaction with students is analysed, which consisted of:

- two separate computer spreadsheet exercises, based on the first few sections of the syllabus, with examples to be solved using spreadsheets generated from scratch by the students;
- a student study habit survey to gain some insight into what students do to study for this subject and what may influence students to pass or fail;
- a short concept test questionnaire to test the students knowledge of thermodynamics concepts gained during the computer assignments, and needed for the first test;
- personal interviews conducted using a semi-structured interview approach, to gain more insight into how students perceive and study thermodynamics.

The four separate major student interventions, outlined above, are discussed in detail below.

3.8 The computer spreadsheet exercises

The two spreadsheet exercises were run sequentially as a logical progression of theory introduction was presented. Once the theory had been discussed in class students would be able to start the assignments immediately. To aid this process both assignments were handed out at the start, so students could work on either or both at the same time. The pace at which students progressed was to be governed essentially by themselves, within the time constraints of the study. They set up their own spreadsheets once the necessary theory had been covered, either during lectures, or by their own studying. The tutorial sheets covering the sections were also handed out at this time so that they could work on them immediately.

3.8.1 Group allocation and filenames

The students were first broken down into teams of three (maximum), following the South African Qualifications Authority (2001, p.36) guideline of "paired or group activities". This was initially done on an ad hoc basis, bearing in mind the warning highlighted by Heywood (2000, p.210) in Chapter 2.4.1.2. Thus group members could swop to other groups, but only for a limited period of time. Each group was assigned a group code for each assignment (see Appendix A), which only they knew, and was used as their file name and placed on all official records. This ensured the anonymity of the groups, and students could not find out in which groups their friends were. Also, from a marking point of view, when assessing another group's project, they would not know who was in the group they were assessing as this code was the only information given to assessor groups at the start of the assessment. Once opened, the assessor team was allocated another filename under which to save the file after they had assessed it, so as not to overwrite the original team's file. Further, each assignment was given a new group code so that they could be recognised independently and also to keep the data for each assignment intact.

3.8.2 The assignment handouts

The handouts for each assignment can be seen in Appendices B and C. For consistency, the layout of each one was kept the same. Also, the instructions and requirements for each task remained similar. The handout gave a detailed description of what was required of each team,

including possible penalties (mainly to do with locking their spreadsheet so that assessor teams would not be able to open it to assess it), the assessment criteria and requirements. They were also informed of the moderation protocol in the handout, being 10% of the completed assignments to be evaluated by the lecturer/marker. It also cited the DIT Rule Book for Students (2006, p.27) pertaining to copying.

3.8.3 The assessment and moderation

Boud (1989, p.26) points out that "students should not expect to do anything unless it is marked." In this project, the mark allocations for the semester appear in Table 3.4. The test 1 mark was divided into two parts, 5% for each computer assignment and 30% for the summative test 1 itself, as described previously in Chapter 3.5. This was to ensure that the work was rewarded, albeit in a small way. Also, if the new assessment method did not prove to be successful then it was not a high stakes component, as highlighted in Chapter 1.4, and hence would not prejudice the students' marks significantly.

To assess the projects in a fair, valid and consistent manner (South African Qualifications Authority, 2001, pp.16-17) a marking rubric, discussed in Chapter 4.1.5, was designed (see Appendices E and F) and put on display at the start of the project, both in the computer laboratories and outside the thermodynamics laboratory. Only the sample problems, discussed in Chapter 4.1.6 and to be solved at assessment time, were left off. Thus the assessment process was "clear, transparent and available to all learners" (South African Qualifications Authority, 2001, p.17) and students were aware of all aspects of the task and its assessment from the beginning and they could use it as a guide at any time. This also made the assessment more legitimate and credible (South African Qualifications Authority, 2001, p.12, 27). It was also an attempt to follow the principle and guideline that students should be able to "analyze, organize and critically evaluate information", one of the required critical cross-field outcomes of OBE (South African Qualifications Authority, 2001, p.24). At the same time it allowed for the assessment of "the learner's peers" (South African Qualifications Authority, 2001, p.36), discussed in Chapter 2.5.1.2. By the time students assessed their peer's work they had done it themselves, so had an idea of the requirements. They would also see alternative ways of completing that task, thus moving around Kolb's Learning Cycle described in Chapter 2.3, reflecting on their own and others attempts at the task. The layout for both assessment rubrics was similar. There were slight differences since the assignment requirements were different, the

most notable one being that a graph was required for assignment 1 whereas it was not required for assignment 2. If one compares the assessment rubrics (Appendices E and F), all three programme exit level outcomes would be used in the assessment process as well as all the programme specific outcomes and many of the assessment criteria (see Appendix L), If one looks at the learning outcomes for the subject (Appendix W) compared to the two assignments it is noted that seven of the twelve components in the Introduction – basic concepts and three of the four Systems and Laws – basic rules section are covered in the computer assignments. These programme specific outcomes and subject learning outcomes are required for the computer assignments, the knowledge of their use being determined in the concept test, discussed in Chapter 3.10, as well as in the class tests detailed in Chapter 3.5.

The sample problems to be solved on the assessment dates were only made available at assessment time, on the assessment rubrics. There were five possible sample problems for each assignment, one randomly given to each group on the assessment day. They were similar to problems the students had solved previously in their tutorials. The answers to these problems, as seen in Appendices N and P, were available on the assessment day from the lecturer and assistants, but only after the students had completed the exercise of assessing another group's work, to cross check the answers and graphs obtained from the assessed spreadsheets.

It has been mentioned by researchers of peer assessment that the marks by students are not necessarily reliable (Haywood, 2000, p.376). Within the intervention was a valuable tool for assessing how well the students were coping with the intervention, namely peer assessment, as it illustrated how well or otherwise they used the tool and also the programme criteria and outcomes mentioned earlier. To further see that the student assessment was fair and valid (South African Qualifications Authority, 2001, pp.16-17) staff were to moderate a portion of the exercises (10% of the exercises as specified in the assignment handout — see Appendices B and C). A moderation weighting factor and an adjustment factor were generated and used in an attempt to normalise the marks. This is discussed in detail in Chapter 4.1.7.3 and 4.1.8.3.

On the day of the assessment each group had to sign a declaration form (see Appendix G), stating that the work completed was their own. If they chose not to have an equal share in the mark allocation then they could declare their weighting of the marks at that time.

3.9 The study habit survey

Fink, & Kosecoff (1985, p. 13) define a survey is a means of collecting data about people's " ideas, feelings, plans, beliefs, and social, educational, and financial background". It can be performed in a written format or verbally as in interviews, as done in Chapter 3.11, both methods being interchangeable (ibid, p. 19) although there are some basic operational differences, the main one being that there can be feedback in an interview to clarify points.

In this instance the survey was to investigate some of the students study habits for Thermodynamics, although these habits would likely be used in other subjects. It was also designed to see if there were any common factors that may help determine a student's success in the subject.

Fink, & Kosecoff (1985, p. 18) suggest performing a pilot test of the survey. It was administered to some of the post graduate students in the department as a trial and a few modifications were made as a result.

The survey form itself (see Appendix H) was divided into six main sections, these being : personal information, information exchange, library use, subject specifics, practical experience/exposure and study techniques. It was required that all questions should be answered other than the last one entitled 'other' which was to allow students to include any other information they wished. Each of these sections and the reasoning behind them is discussed below.

3.9.1 Personal Information

This section had six sub-parts. In the first part students were asked to state their senior certificate symbols. As in most tertiary institutions in South Africa, the majority of students accepted into the Mechanical Engineering Department have met certain Senior Certificate symbol requirements. These are a minimum symbol grade for Physical Science and Mathematics, together with English with a minimum of a pass at standard grade as a second language. Students are thus accepted into the institution based solely on these symbols (Durban Institute of Technology, 2005a, p.3; Durban Institute of Technology, 2006a, p.6, Durban Institute of Technology, 2006b, p.12). There are however alternative routes for acceptance into the programme, described in the Departmental Handbook (DIT, 2005a, p.3), but this did not

apply to anyone in this study.

It is always assumed that the better the symbol the more likelihood a student has of successfully completing their diploma, preferably within the minimum time allowed. Unfortunately this is too often not the case. In this study, only one subject, a science and mathematics orientated one, was being investigated and not the entire Diploma course, so only Physics and Mathematics symbols were requested. In addition, since there are a large number of second language students being accepted into the system, it was decided that the English symbol may also be relevant. Other languages and their symbols were requested as well. Hence, the second part was simply a request to elicit whether a student was using English passed as either a first or a second language.

The third sub part was to determine in which ethnic group a student fell. There are four main ethnic groups in South Africa, these being Black, White, Coloured and Indian. As mentioned in Chapter 1.7.1 the racial divide of the class was fairly typical of the countrywide racial divide, except that there are more Indians in KZN due to history of immigration. However there are other minority groups outside these four categories, hence an "other" option was included.

The fourth item in this section was to determine the highest qualification of the students' parents or guardians. This part was divided into three broad categories: less than grade 12, grade 12 or greater than grade 12. Generally it was assumed that better educated parents are more likely to encourage their children to obtain a good education. In a report by Lam et al. (2010, p.11) comprising of 4752 people aged 14-22 from the Cape Area Panel Study, of which 48% were coloured, 32% African/black and 19% white, the "mothers and fathers of African youth have around four years less schooling than the parents of white youth, with father's schooling missing for 44% of Africans" (i.e. parent is not co-resident in household). In it they suggest that parental education can have a significant impact on the probability of secondary school leavers enrolling for tertiary education (ibid, p.19).

The fifth statement was simply to determine if a student was repeating the subject. Since the pass rate in this subject is generally in the region of 40 to 60%, it is expected that a fairly substantial portion of the class would be repeat students. This, theoretically, should give those students a fairly good chance of passing as they had seen and done the work already. They also had the advantage of being able to carry over their practical marks (Durban Institute of

Technology, 2006a, p.8), thus reducing their workload.

Finally the last statement in this section requested students to indicate what percentage they were hoping to achieve in this subject. It was envisaged that this would give them a specific goal to work towards.

3.9.2 Information Exchange

The second section was to get some idea of how much students used modern means of information exchange. It was divided into two parts, the first being computers and their use. This had two questions, the first one being to determine the most likely and most common place where access was gained to a computer and the second statement was to get a feel for how much time students accessing information in a week outside the computer laboratory sessions. Some of the uses may include those mentioned in Chapter 2.2.3 and Chapter 2.2.4.3. O'Brien & Symons (2007, p.412) cite one university in Canada, with over 4000 full-time students, providing each student with a laptop to use for their studies. If that is the future trend South Africa has a long way to go.

The second part, also with two statements, was to determine if students owned a cell phone or other similar device, and to what means they used it. Since the modern cell phone can be used to perform numerous tasks other than simply chatting, verbally or textually, they can be a powerful tool to assist students in finding valuable, or otherwise, information, including internet browsing. They can also waste a student's time and be a significant distraction during lectures and other formal contact times. Lipscomb, et al. (2005, pp. 50,52), in a study of 383 cell phone users in the United States included in their study etiquette of cell phone use, including in university lessons. Their findings indicate that students in general agreed that it was inappropriate to use them during lessons. This was in agreement with other studies considering inappropriate use in class ((Wise, 2003; Moore et al., 2002; Rosmeyer, 2002), as cited in Lipscomb, et al., 2005, pp. 49-50). Another concern is the use of cell phones to cheat in exams (Batiste, 2004; 'Lesson no. 1', 2004; Roberts, 2004), as cited in Lipscomb, et al., 2005, p.50), a growing concern at many Institutions in South Africa, including the DUT.

3.9.3 Library Use

This section was included in an attempt to find out how much use students made of the library

facilities. There were four statements. The first was to see if they had ever done a library orientation course. All students should do this during their first few weeks on campus, as mentioned in Chapter 2.2.3. The second question was to find out if they had ever requested the assistance of any of the librarians listed in their learner guide (Thurbon, 2006b, p.9) during visits to the library. In their study of library use O'Brien & Symons (2007, p.414) found that "science students (49%) were more likely than other students (humanities, 22%; social science, 30%; professional studies, 24%) to never consult a librarian or visit the reference desk" and that 23% of science students never used the library to find books or journals. They also found that science students were the least confident in both finding relevant information and knowing how to find the material (ibid, p.418). The third and fourth statements were to determine the frequency with which they used the library and if so to what use do they put it.

It is noted here that the Researcher failed to ask one of the most important questions and that was to see if students utilized past papers, an important resource, to assist in their studying and revision for tests and examinations. This oversight was dealt with by adding it to the interview questionnaire.

3.9.4 Subject Specifics

This section had two parts to it. The first part consisted of two statements relating to notes and textbooks, to determine their primary source of data, other than their class note taking. As mentioned in Chapter 2.2.2 they have the option of either photocopying a set of basic but comprehensive notes provided in the library, possibly for financial reasons, or they can purchase the recommended book. However, it was explained to students at the beginning of the semester that this prescribed book is often not enjoyed by the first-time user, but is an excellent reference once one has got an understanding for the subject. An alternate book often preferred by first-time users, was a book previously prescribed for this subject and subsequent follow-on subjects, costing approximately the same as the current prescribed book, although earlier editions of it did not cover all the sections required for the follow-on subjects, hence the current recommended book. There are many other good thermodynamics books available in the library that students can utilize if they so wish.

The second part of this section dealt with how much time, in hours, students devote to studying thermodynamics per week, what type of activities they do during this time and finally what

portion, as a percentage of this time, is spent on each activity.

In a study of college students in Nigeria by Emenalo (1989, p.18) he found that students did not spend enough time studying at around two hours per student per week, done at week-ends. Student study time varies quite considerably and is likely to be dependent on the discipline. Rau and Durand (2000) (as cited in Plant, Ericsson, Hill, & Asberg (2005, p.97) reported students study time at the University of Michigan to be 25 hours per week, but was not necessarily "representative of students in most large state universities". They further report that whereas students at the Illinois State University studied only eight hours per week, "real benefits were only seen for students studying over 14h/week", which was only done by 25% of the students. If one averages the study time for a typical semester consisting of five subjects at the DIT, that would equate to anywhere between one and a half and five hours per week per subject. In Plant, Ericsson, Hill, & Asberg's (2005) study they suggest that it is not only the quantity of study time that can affect the improvement of grades, but also the quality of study, as described in Chapter 2.1.8, with less study time required to achieve the same result for better quality study.

3.9.5 Practical Experience/Exposure

This part dealt with what students had done since leaving school. Atherton (2002b, para.9) refers to what a large difference industrial exposure can have to "students' learning".

The first question was simply to see if students had worked, in whatever form, since leaving school. Working often leads to increased maturity and responsibility, and can be a major motivating factor for students to succeed. Kuh (2010, para4) says that work experience can help a student obtain valuable workplace skills such as "teamwork and time management" and that several colleges in the United States actually encourage it (ibid, para5). However, gaining appropriate work profession related work can often be more difficult.

The next two questions dealt with firstly, an exposure to engineering in general, students being requested to specify the type of engineering exposed to. Secondly students were requested to state if they had been exposed more specifically to any thermodynamic equipment or situations in any working environment and then to list what areas those were, such as boiler plant, refrigeration or air-conditioning, engines, compressors or any other related equipment. This form of exposure can be a great motivating factor in that students can then relate to what is

talked about or conceptualised in class. Without this exposure students often feel alienated, and since large items of machinery cannot be brought into the classroom for demonstrations, they do not relate to the equipment under analysis.

3.9.6 Study Techniques

The last part of the survey revolved around how students go about their learning. It consisted of two parts. The first part related to a table considering learning styles together with a statement and the second part was a series of eight statements, with multiple choice answers for each.

The first part, the table was to find out what a student's preferred learning style was. Early ideas were influenced by Felder and Soloman's ILS (Felder, & Soloman, 2005), having four groups of opposing styles of learners, namely sensing and intuitive, visual and verbal, active and reflective and sequential and global. This was in part due to the Researcher's having attended a two day workshop run by Felder and Brent in 1999, as highlighted in Chapter 2, but also because many of the students who had utilized their surveys were engineering students. However, the feeling was that students would be unfamiliar with the terminology mentioned by Felder and Soloman without detailed explanation, hence a simpler approach was embarked upon. The VARK model, as discussed in Chapter 2.1.4.1., was chosen as it was something that students could probably relate to without much prompting. Students could add further dimension to them by choosing more than one, ranking them if they wished, by simply filling in the last column of the table. The statement below the table was simply to determine if students had indeed visited a web-site to determine their own learning style preferences as suggested in their learner guide (Thurbon, 2006b, p.9).

The last six statements revolved around the "how" and "what" students do in going about their general daily routines when learning new work. The first, relating to group work, has become popularised in the literature as a learning format, as mentioned in Chapter 2.2.6 and encouraged by the CCFO's of SAQA (South African Qualifications Authority, 2001, p.24). It has also been observed by the Researcher during interactions in and out of the classroom with students. Boehler et al. (2001, pp.269) reports that students who studied in groups showed a slightly higher score compared to those who didn't. Plant, Ericsson, Hill, & Asberg (2005, p.101) suggest "choosing study environments with a low probability of distraction (e.g., studying alone in the library)" for better quality study, as described in Chapter 2.1.8.

The second statement mentioned note-taking, done by almost every student. How they go about doing this is probably an acquired and preferred style. Some of the alternatives that students may use were mentioned in Chapter 2.1.8. Boehler et al. (2001, pp.270) investigated ways that their students take notes during lectures, described in Chapter 2.1.8. As all the students in the class are generally seen taking notes themselves, with no one recording lectures, only the rewriting and adding to notes was considered along with its frequency.

The third statement related to the student's Learner Guide (Thurbon, 2006b), as mentioned in Chapter 3.8.3 in reference to the programme specific and subject learning outcomes, highlighted in Appendices L and W. It is mandatory to hand the Learner Guide out at the beginning of every semester for each subject. They contain detailed information about the subject, the lecturer, the purpose, the requirements, the assessments and assessment criteria, reference material, rules and policies and so on. The Researcher always goes through it in class in detail, pointing out important and relevant information, and any future queries associated with the information therein are directed straight back to the document. They are thus important sources of information for students and should be consulted as and when necessary. Students who fall foul of DIT rules often do so despite having the information in the study guide and rarely realise it until they are found guilty of the offence.

The next two statements were associated with the tutorials and the attendance thereof. It has been noticed in recent years that student attendance at the tutorials has dropped. To assume that this is because the students have completed all their work and know exactly what's going on is somewhat wishful thinking. Emenalo (1989, p. 18) concluded that there were no tutorials but that they are "very powerful aid to teaching" and recommended that they should be a compulsory component of the teaching.

The last statement on what students do before a test was put in somewhat facetiously. The Researcher had tried all the methods suggested in the survey during his own years as a student, as most students surely have, not always with successful outcomes. It was interesting to note what answers would be given to this question.

3.10 The concept test

The concept test (see Appendix D) was designed to test the student's individual ability to apply the theory learnt over the previous weeks, during the development of the computer assignments and covering the use of many of the programme specific and subject learning outcomes, highlighted in Appendices L and W, and discussed previously in Chapter 3.8.3. It was presented in the form of a spreadsheet requiring only Boolean inputs (yes (=1) or no (="blank")).

It was laid out in a spreadsheet format (using Quattro Pro version 9) over five separate pages. The first four pages posed multiple choice questions, and the students chose the correct answer by placing a 1 next to the chosen solution. The questions on each of the pages had a supporting graph or diagram relating to specific concepts and ideas associated with thermodynamics and the particular diagram. These pages can each be seen in Appendix D (Concept Test Pages 1 to 4), as they would have appeared to students.

At the same time it had the inbuilt ability to check the students' answers, add up the score and display the result at the end of the test to give them immediate feedback as described in Chapter 2.2.4.1. It can also be a powerful motivator as described in Chapter 2.1.6. This score was not a part of their formal class mark, but purely a formative test score. The final result was presented as a percentage figure for the test as a whole. It was further broken down into the four main sections that were tested, one associated with each page. The section breakdown can be seen in the final score output page, Appendix D: Concept Test page 5 and discussed further in Chapter 4.3.3. Students could see straight away which section was their best, and which was their weakest. This could then be used as a revision tool for further study before the main test, which was written a couple of weeks later. Thus immediate formative feedback was available to the students, as recommended by the SAQA Assessment Document (South African Qualifications Authority, 2001, p.26).

3.11 The interviews

Interviews can take on various forms. They are generally either structured, semi-structured or unstructured (Esterberg, 2002, p. 85; Denscombe, 2003, p. 166-167; Fontana and Frey, 1994, p.361, as cited in Punch, 2005, p.169). Gillham (2000, p.62) proposes that the power of the "face-to-face interview is the 'richness' of the communication". They can be one-on-one interviews with only one interviewer and interviewee or group interviews, with about four to six

participants (Denscombe, 2003, pp. 167-168). Both have their advantages and disadvantages.

The advantages of one-on-one interviews are that they are easy to arrange, only two people typically being involved, the views expressed by the interviewee are theirs alone and they are fairly "easy to control" (Denscombe, 2003, p. 168). On the other hand group interviews can generate discussion leading to "consensus views" and "generate richer responses" (Lewis, 1992, p. 413, as cited in Denscombe, 2003, p. 168). However, it can lead to only the viewpoints of those who may "dominate the talk" or to a common opinion that is "perceived to be 'acceptable' within the group" (Denscombe, 2003, p. 168), but one that is not necessarily shared by all members present.

All the interviews were taped and videoed for later transcribing. The interviews were timed to be a maximum of thirty minutes. In this instance semi-structured interviews were chosen as they follow a set pattern in which certain topics can be covered, but which allow the interviewee to speak openly and freely about their answers to questions posed (Esterberg, 2002, p. 87; Denscombe, 2003, p. 167). Gillham (2000, p.65) argues that it is the most important type of interview for a case study. As the interview data collected was of a qualitative nature it would be analysed in that manner in Chapter 4.4, all the other interventions mentioned previously being more quantitative in nature and analysed as such in Chapter 4.

One also has to be aware of the power of the interviewer in this situation, in this instance the Researcher, who was also the subject lecturer. This can lead to responses that the interviewee may perceive that the interviewer wishes to hear (Denscombe, 2003, p. 170). As some students were English second language students a colleague from the department sat in on some of the interviews to assist with any statements students wished to make if they felt that they could express themselves better in their home language. This was to ensure continuity of the conversation if this aspect arose. This aspect was pointed out to them before the interview began.

This component of the research would fall within an interpretive paradigm, discussed in Chapter 3.2.2. However, the Researcher is also aware of his positivist background, which can influence his interpretation of the data. Jarvis (1999, p.127) states that the interviewees "responses are social constructions, and so are the researchers' interpretations to those responses". As the interviewer has his own views of reality he could be interpreting the information gained in the

interviews subjectively and must be careful in the interpretation or meaning of what is said. In this study the Researcher's narrative however is a "*secondary account*" (Neuman, 2000, p.74) since he is interpreting another's meaning of social interaction. This also leads to the external validity, mentioned in Chapter 3.2.2, of the data revealed in the interviews and if it can be used to generalise opinions realised by the data.

3.11.1 Choice of students

 The students to be chosen for interviewing were to be selected based on their final class mark score for the semester, since it was a combined mark for all the assessments done during the semester. Purposive sampling (Fink, & Kosecoff, 1985, p.59) was the method used to choose the students, who were chosen over as wide a range of marks as possible, from a failure (<40%, the subminimum for eligibility to write the examination at the end of the semester (DIT, 2006a, p.8)) to the highest scores achieved. Those chosen for the interviews were given a letter beforehand (see Appendix X), as suggested by Denscombe (2003, p.8), inviting them to make an appointment at a time suitable to them and the Researcher. A further group were chosen as backups, also chosen by purposive sampling using the same criteria.

3.11.2 Choice of questions

As the interview was a one-on-one and semi-structured it was under the control of the Researcher who wanted to find out how students go about studying for Thermodynamics, incorporating sub questions 1 and 2, introduced in Chapter 2. It also incorporated aspects of the main question as some of the questions related to how students found the two ways of learning, namely the constructivist approach, as detailed in Chapter 2.1.7, versus typical lectures mentioned in Chapter 2.1. Thus the questions chosen were directed towards this goal. Gillham (2000, p.67-68), as does Esterberg (2002, p.94), recommends having a standardized set of questions to cover all aspects of the planned interview, together with prompts and alternative questions for flexibility. A plan of questions to pose together with keyword prompts and alternative questions and their order appears in Appendix I, several based on sample questions as proposed by Gillham (2000, p.68). Hence students were given scope during the interview to deviate from the topics if a new area of interest opened up and also to ask questions of the Researcher. The questions were not only specifically directed at the student but also indirectly to allow them some freedom to talk about what they felt others did.

3.11.3 Tools for analysis

Esterberg (2002, p.176) says that most researchers will use a computer somewhere in the process, even if it is just transcribing the interviews. However, there are various methods that one can use to analyse the interview data, from reviewing the typed script manually to the use of computer programs, although these can be fairly expensive (ibid, p.177). Some of the programs available include Nvivo , The Ethnograph, HyperESEARCH, and Atlas.ti (Esterberg, 2002, p.178; Yin, 2009, p.127). Nvivo was in use by UKZN. Another program, available from the web was Transana. Both were considered for the job. As a quick comparison of the two programs mentioned, Table 3.6 below shows some of the points to consider about each one.

Nvivo was introduced via a short course to grasp the basics, but there was still a further learning curve to get it operational. Transana version 1.2 was introduced late in the process and became available immediately from the internet and was quickly up and running. However, it had its drawbacks, one being the video format limitations, avi and mpeg1. As the video data came out in mpeg2 format, this immediately created operational problems within the program. However, a Beta version 2.2 was available from the program's Author's and this eliminated some of the problems immediately. It did not eliminate all of them, leaving the transcribing functions of little use (control -A, -D and -F wouldn't function and -S did not rewind two seconds as specified). An initial run through the recording was done by an external transcriber followed by a run through by the Researcher using Voice Studio software used by the digital recorder utilised to record the interviews. Most transcribing was completed using a word processor and Cyberlink Power DVD software, whose speed variation controller and rewind facility were quite useful for the transcribing task.

The downside of interviews can be the time taken to transcribe them before analysis can begin. Jarvis (1999, p. 126) indicates that it can take "ten or more hours" for each hour of taped interviews and Baxter, Hughes and Tight (1996, as cited in Jarvis, 1999, p.126) suggest "seventeen hours".

Next the data needs to be coded (Yin, 2009, p.128) or "indentifying substantive statements" (Gillham, 2000, p.71), whereby key words or phrases are highlighted and then the transcripts are searched for these words to see how often they appear in each transcript. Programs like Nvivo can search for these words automatically, whereas Transana has to be manually programmed, using time coding, to highlight the words in the text. Only once this is done can

one start the analysis. The coding details are described in Chapter 4.4.

Table 3.6: A brief comparison of two transcript analysing programs

COMPARATOR	NVIVO	TRANSANA
Cost	Expensive start-up cost as a license is purchased by the Institution or Researcher.	Cheap starting cost as is freeware down loadable from the web. Donations are requested towards further development costs (Note 1)
Training time	Takes a fair amount of practise before one becomes proficient at it	Is fairly quick and easy to get started as not much skill required to get it running
Ability to search document for words or phrases	Can find words or phrases in your document to add to data	No search facility built in and only able to find things once time coding is put into document manually, which can take a fair amount of time
Coding and build up of "pictures" of data	Automatic search for words or phrases. Can set up related items and sort them into family groups, and then build up further relationships.	Once time code is done then one can extract words or phrases of interest and build up relationships amongst them, all done manually, but once there can search collections and build up other common groups of data
Help support	Unknown, but assume available on the web	web support is available and response time to queries fairly good. Also have working groups going on the web to assist the learning process.
Data considered	Accepts transcribed documents in .rtf file format only	Accepts transcribed documents in .rtf file format only and is synchronised to a video file, in .avi or .mpeg formats, and a voice (.wav) file once the time codes are in place
Problems	Not enough time spent on it to cause or find problems	Has some initial programming problems and file format limitations, but new releases are improving it

Note 1:   Subsequent to this study the policy has now changed and it is now required to
purchase a copy prior to use

CHAPTER 4

ANALYSIS OF DATA

4 Overview

The four separate major student interventions formed the predominant part of the study, the methodology of each was discussed in Chapter 3.8 to 3.11. However, the bulk of the class marks (90%) came from the normal summative exercises performed during the semester. An analysis of the test marks also forms part of this chapter. Since different types of data were acquired, different styles of analysis, both qualitative and quantitative as described in Chapter 3.2, will be used in analysing the data. The data, with its respective allotted mark was seen in Table 3.4 and discussed in Chapter 3.5. Although the mark allocation is not equal for each exercise, as seen in Table 3.4, the interventions were all equally important and will be analysed in detail in the following section, either quantitatively or qualitatively, or both:

- The Computer Spreadsheet Exercises, in 4.1
- The Study Habit Survey, in 4.2
- The Concept Test, in 4.3
- The Personal Interviews, in 4.4
- The Semester Test Marks, in 4.5

Of the approximately 127 students who initially arrived to start the subject, 120 were finally registered, ten de-registering at various times during the semester. This made it one of the largest classes the Researcher recalls and about 30% bigger than anticipated, based on recent historic registrations. This created a number of problems along the way, highlighted in the respective sections. The number of students who participated in each exercise in the intervention, is indicated in Table 4.1 below, both as a scalar quantity and as a percentage of the total class who remained registered for the duration. It can be seen that the majority of students participated in the exercises even though only the two spreadsheet exercises counted towards their class mark, the other exercises being essentially voluntary.

Table 4.1: Numbers of students participating in each research exercise and percentage (based on 120 registered students)

Exercise	Number	Percentage of registered students (%)
Spreadsheet exercise 1 assessment	112	93
Spreadsheet exercise 2 assessment	80	67
Study habit survey	96	80
Concept test	82	68
Interviews	9	8

In Table 4.2 the number of students who participated in the compulsory activities, i.e. tests, Thermodynamics laboratory practicals and examination during the semester is indicated. The number of students indicated in each table is comparable indicating that most students were willing to perform the tasks highlighted in Table 4.1.

Table 4.2: Numbers of students participating in each normal class activity (based on 120 registered students)

Exercise	Number	Percentage of registered students (%)
Test 1	103 + 8 supplementary	93
Test 2	106 + 2 supplementary	90
Practicals	113	94
Semester Examination	94	78

4.1 The Computer Spreadsheet Exercises

Introduction

The computer spreadsheet exercises were where the main teaching and learning were to take place. The setting up of the tasks is discussed in detail in Chapter 3.8. Once groups had been formed, discussed in Chapter 4.1.1, they could begin the assignments immediately. Several

weeks later, having completed the assignments, each group's spreadsheet was assessed by another group, discussed in Chapter 4.1.4.5 and 4.1.5.5. As the assignment handouts indicated a sample of them was to be moderated, discussed in Chapter 4.1.4.6 and 4.1.5.6.

4.1.1 Group allocations and filenames

The setting up of the groups, their members and their assigned codes, to be used as their filename, was introduced in Chapter 3.8.1. Although the original plan was to run with teams of two, the large class size mentioned earlier did not allow for this. Another problem was that of late registration, students still being allowed to register six weeks into the semester, thus allowing students to arrive and start the subject near the end of the actual intervention time period. As mentioned in Chapter 3.8.1, the groups were initially allocated on an ad hoc basis and students were allowed to swop teams during the first computer laboratory session if they wished. Several people took this opportunity which occupied the Researcher's time for most of that session, leaving little time to assist students in other areas.

Preparations had originally been made for 45 groups of three to do each assignment. Forty-four groups ended up starting assignment 1 and five groups did not complete it either due to deregistration, dropping out, or being absorbed into other groups. That left 39 groups to complete the exercise and also to assess another group's work.

There was one problem associated with the codes that had been allocated to each group to be used as their filename. One group managed to get another group's file name at the start and both shared this same code for the entire assignment 1 exercise. The fact that both groups then had conflicting spreadsheets, which kept changing weekly, did not appear to alert them to the problem, until assessment time arrived and only one file presented itself for assessment. The solution to this problem is discussed in Chapter 4.1.4.5.

The group allocation is mentioned in Chapter 3.8.1. Although an option was for groups to be changed for each computer assignment this was never implemented because the problems this would have created would have wasted more time. Hence each group stayed as they were for both computer assignments.

The second spreadsheet exercise seemed to go more smoothly as students seemed to have got

the idea of the use of the code for their file name. Also by the time the second assignment was underway the groups had settled down and there was no further movement into or out of the class, other than late registrations. As in the first exercise, preparation had been made for 45 groups of three to do this exercise. Of the 37 groups who started this exercise, only thirty assessment rubrics were eventually issued (Appendix G) with only 21 groups completing the exercise by returning the assessment rubrics. It was not ascertained as to why the others did not complete the exercise.

4.1.2 The assignment handouts

The assignment handouts, as described in Chapter 3.8.2, were both distributed at the start of the intervention and the assessment rubrics put on display as mentioned in Chapter 3.8.3. No comments or queries were initially received from students about either the instruction sheet or the rubric. It was therefore initially assumed that all the groups understood the tasks to be performed. It soon became apparent that this was not so, due to several queries as to what was expected of the students in dealing with the assignment. These were solved mostly in one-on-one conversations during the computer sessions. A lecture period had also been set aside a couple of weeks into the project specifically to provide a question and answer session on anything to do with the assignments. This proved to be useful as several problems were highlighted and solutions discussed then and there. One of the problems that surfaced was that many students did not know how to set up an equation in excel, raising a value or variable to a power, an important requirement for both the assignments.

4.1.3 Computer session attendance

Attendance at all sessions was monitored by taking a register. Table 4.3 below, shows the attendance at each session, together with a percentage of 120 students registered for direct comparison to Table 4.1. It can be seen that sessions three and four have a second tally. This was because the sessions were three periods long, and a second round of attendance registers were distributed, usually in the third period. This was done in order to see if students remained for the full session. The large reduction in numbers showed this was clearly not the case.

Table 4.3:   Summary of signed register attendance at each computer laboratory session

Session	_1_	_2_	_3_	_3_	_4_	_4_	_5_	_6_	_7_
Date	2/08	9/08	16/08	16/08	23/08	23/08	30/08	6/09	13/09
Attendance	77	0	109	42	102	18	102	60	68
% (of 120)	64	0	91	35	85	15	85	50	57
Description		Public holiday		2nd register		2nd register	Assess-ment 1	Concept test	Assess-ment 2

However, it is noted that no head counts were taken to verify these numbers due to time constraints and availability of staff to perform this task. Questions raised by students on assignment issues, and difficulties during each session, mostly with computer-related problems as mentioned later in Chapter 4.1.4, left little time for staff to do head counts. The registers however were unreliable as an accurate attendance record, as the student signed declaration slips completed at each assessment session indicated attendances of 112 and 80, as seen in Table 4.1, as opposed to 102 and 68 on the weekly signed registers seen in Table 4.3. Also the concept test register showed 60 attendees (session six in Table 4.3) versus 82 actual returned concept tests from the exercise on that day. Reasons for these differences were not ascertained.

There are, however, several possible reasons for the change in attendance numbers towards the end of the sessions. Firstly, the fact that some students, mainly repeats, had clashes with other subjects during some of the periods. These students had made mention to this fact early on in the project and were free to come and go as required. However, this did not involve many students and certainly does not account for the difference in numbers indicated by the attendance figures. Despite this their team mates were still required to carry on with the task even if all members were not present. Most teams carried on in this fashion. Secondly, students may have left because of their frustration with the problems experienced with the computers, as highlighted in Chapter 4.1.4. Students often had to wait around to continue their tasks whilst the entire networked system was rebooting. This happened on numerous occasions, sometimes leaving the students idle for up to twenty minutes or more.

Probably more importantly towards the end of the sessions was also the time in the semester that the students were generally involved in the first round of tests for other subjects together with test 1 for this subject, which alone counted 30% towards the class mark, coming up soon

after assessment 2. This may have contributed to low attendance figures and a lack of enthusiasm to attempt a new style of assessment, even though they had already done it once in assessment 1.

Further, looking from a Positivist Paradigm approach, the preferred Paradigm of the Researcher, it was not anticipated that students would not stay for the time allocated for each session. As students only had limited time available it was envisaged that they would use it as productively as possible. They had been told before the start that the Researcher was not aware of another study that had been done in this manner and that it was likely that some unexpected problems would occur along the way. He also said that they would be dealt with as they arose, which he made every attempt to do.

4.1.4 Computer related Problems

Mehl and Sinclair (1993, p.8), as mentioned in Chapter 2.2.4.2, found that there was a problem with control with more than 30 terminals. The fact that the class was about 30% larger than originally expected, leading to about 40 terminals in use at any one time was further exacerbated by not all 40 terminals in each room (as seen in Table 3.5and discussed in Chapter 3.7) being operational, causing the class to be split between two rooms. Thus the two supervising staff (the Researcher and his assistant) had to continuously move from room to room. A lack of cooperation by some students getting on the internet during the sessions despite numerous requests not to do so made the laboratory sessions more difficult to control, wasting valuable time.

Besides the filename problem discussed in Chapter 4.1.2, there were other problems associated with the computers in the venues S9-001 and S9-006 which were all linked to a server located in room inside another adjacent computer laboratory. These problems included:

- Accessibility - the venues were booked for the sessions required to complete the exercise and closed during the day until 16h30 after which they became open access for all students. This meant that the students in the class could use them during the booked time but could only get back to them in the evenings, not always easy for students living far away. However, it was envisaged that the exercises given were to be completed in the time allocated to the sessions, so this should not have been a major problem. It was also found that other students would

wander in during booked sessions and just start using the computers without asking.

- Internet access - as mentioned in Chapter 2.2.4.1, Race (1999, p.64) talked about students being distracted by inappropriate things. All the computers were linked to the Internet via the backbone system installed in the laboratories. This meant that all students had access to the Web during the sessions. This alone proved to be a major stumbling block, as several groups of students spent time surfing the Web and not concentrating on the exercises. Students used Googleearth, surfed the web, downloaded software and so on. At the end of one session, walking past one computer the words "Game Over" popped up on the screen. This had a detrimental impact on speed as it noticeably slowed down the refresh rate of the computers. Despite warning students not to surf the web, and closing down these websites when they were discovered, this problem continued to plague all the sessions. This also led to another problem, viz. viruses.

- Viruses - this became one of the major problems and caused much lost time in the two computer laboratories. Viruses were brought in either via the Web or student's personal memory sticks. The anti-virus software working in that Laboratory, Sophos, would lock onto a machine with a virus, consequently slowing down the system refresh rate as the virus was isolated and eliminated.

- Theft - at least one student's memory stick was stolen during one of the sessions. This was never returned, the student losing all his work including the computer assignments.

- Unplanned interruptions - there were unplanned interruptions to the weekly laboratory sessions. This included a public holiday on the first session date, putting the entire schedule behind. This was an oversight on the Researcher's part as he was only given the go-ahead a couple of weeks before the start, and failed to notice the public holiday on the calendar. Management also chose another session slot for the entire institution to fill in a student satisfaction survey.

- Loss of data – due to the various interruptions caused by reasons mentioned above several groups lost their latest work. This was because when the server hung and they hadn't saved recently, despite many warnings to save regularly, they would lose all the work they had done in the session up to that time.

At the start and end of each session, the idea was to download all information and files generated by the students, as a backup, onto a memory stick via the main server's controlling computer. This proved to be necessary, but not totally reliable. Although these measures were taken this proved ineffective for several reasons:

- limited assistants available to help, and time constraints to do it oneself

- viruses corrupting the system, some of which got onto the server with Sophos deleting items that were infected and thus files were lost. This also disrupted continuity

- students' inability to correctly locate and save their files in the allocated folder. Even though this was the only designated and allowed folder as set up on the server, they did not always use it, often using their own memory sticks and leaving nothing on the hard drive. This was further compounded by the virus problem, so the primary allocated folder had to be found by backdoor means on several occasions.

However, most data was saved and reusable because of it. The Researcher has to thank his assistant supervisor, as his knowledge of computers and network systems saved the day more than once in getting the tasks going and preventing further crashes or opening up new paths to access required data. Where students had to access information and exercises via alternative back door routes set up whilst the sessions were underway, this again wasted valuable time as this information had to then be passed onto students in the two computer laboratories before things could get underway again. Further to this the memory stick being used by the Researcher also became corrupt and some of the data from the weekly computer laboratory sessions was lost. This may have been caused by a virus or just a faulty stick.

4.1.5 The Assessment Rubrics

The assessment rubrics for both computer assignments, as discussed in Chapter 3.8.3, were set up in a similar manner, both using Likert scales to assess the assignments and both using the same criteria and evidence for measurement of performance, as seen in Appendices E and F. The only exception was the last criterion in the table viz. "Document coherent", which in Assignment 1 referred to a graph, as seen in Appendix E. Since there was no graph in Assignment 2, this component was removed, as seen in Appendix F. Some descriptive detail relating to valid evidence was added to the tables for clarification, to assist the students with the task.

The criteria for measurement of performance were divided into four categories related to the subject's specific outcomes, as extracted from the Learner Guide Specific Outcomes and Assessment Criteria Table (Thurbon, 2006b, pp. 4-5), seen in Appendix L. The rubric criteria

can be cross-referenced to the specific outcomes for the subject as indicated in Table 4.4 below, keeping them in line with the SAQA assessment guidelines of validity and reliability (South African Qualifications Authority, 2001, pp.17-18).

Table 4.4:   Rubric Assessment Criteria on Likert Scale cross referenced to appropriate Subject Specific Outcomes, detailed in Appendix L

Rubric Criteria	Specific Outcomes cross reference
Definitions, terminology and symbols	1.1
Equations, data, notation and units	1.2
Information use	2.1
Document coherent	2.1, 3.1, 3.2

At the same time, many of the critical cross-field outcomes (SAQA, 2001, p.24), contained in the second Table of Appendix L, were required to complete the two assignments, namely : creativity, teamwork, organisation, data gathering, communication, technology use, reflection, responsibility and social awareness.

The Likert Scale, as seen in the Appendices E and F, was a five choice scale, with the scale referenced from "strongly agree" to "strongly disagree", together with some further description about evidence and the relative amount. Again it was used for both assignments for consistency.

4.1.6 The sample problems

There were five different sample problems generated for each assessment exercise, performed at the end of each assignment and added to the assessment rubric form described in Chapter 4.1.5. Each of the problems for both assignments was of similar difficulty and requirement. The five questions appear in Appendices M and O for assignments 1 and 2 respectively, only one of which would appear on an assessment sheet at random, in the space provided. The questions respective answers are depicted in Appendices N and P for assignments 1 and 2 respectively.

Space was left on the rubrics to show any working required before the information could be placed into the spreadsheet, for example if unit conversions or process end points were required. This space was used by some assessors to manually perform some or all of the calculations required, defeating the object of the exercise. It was the assignment's spreadsheet that was

supposed to perform the required calculations to achieve a final answer. Although there was a place to write down the final answer, no mark was allocated to it.

One of the main objectives of the assignments was to get students to use and understand the syntax and terminology of thermodynamics correctly, together with the appropriate process equations, which are related to the learning outcomes mentioned in Chapter 3.8.3. Hence, in this case, an accurate answer was not significant mark component. Consequently, all the marks came from how the rules, laws, symbols, processes and terminology of thermodynamics were used to generate the spreadsheet. The assessments therefore relate to the subject's specific outcomes, mentioned in Chapter 4.1.5 and cross-referenced against the assessment rubrics in Table 4.4. It was thus easy to obtain high marks if correct use was made of the specific and learning outcomes associated with thermodynamics.

The mark allocation for these assessments is in contrast to that in the class tests, where marks are shared typically between methodology and answers, syntax and layout being left out in the mark allocation. Obviously correct answers can only be obtained by using the appropriate equations correctly with the correct data in the required format, which should have been visible or mentioned in the spreadsheets. Students should gain the necessary skills and knowledge to do this by interacting thoughtfully with all the subject content and requirements, including doing their tutorials and other such exercises, which was part of the laboratory requirements since tutorial time was included in the periods assigned to the computer laboratories, as highlighted in Chapter 3.3.

4.1.7 Spreadsheet Assignment 1 - Processes and Closed Cycle Analysis

4.1.7.1 The Assessment

As this was very likely the first time students have faced assessing their peers ideally, as highlighted in Chapter 2.5.1.2, students should perform some formative peer assessment as training. However, due to the time constraints of the project this was not possible. As the rubrics, discussed in Chapter 4.1.5, had been up in the computer laboratories for several weeks, students had had adequate time to study and utilise them if they wished. Before the first assessment took place the Researcher spent some time in class going over the rubric to explain what students were to do for the exercise. The assessor teams were to assess their allocated file as a whole, using the assessment table, graded on the Likert scale, mentioned in Chapter 4.1.5.

They also had to write down their comments in the spaces provided, stating the assignment's good points and areas for improvement.

Only three rubrics did not have written comments in the spaces provided. The student comments varied widely and a copy of these appears in Appendix J, for assignment 1, reproduced verbatim from each rubric form, with staff assessment comments tabulated below with a cross reference to students comments. It also has a comment on the final outcome of their graphs in that spreadsheet. Students' comments for Assignment 2 appear in the table in Appendix K.

4.1.7.2 Analysis of the Answers and the Graphs for Assignment 1

Of the 39 assessed assignments, only eight answers were placed on the rubrics as seen in Appendix E. None of these answers was correct. Twenty-six rubrics had graphs drawn on them by the student assessors, taken from the spreadsheet they marked, indicating that the graphs were included in the spreadsheets as required by the assignment. Of the solution sketches drawn on the marking rubric, only two were conceptually graphically correct, as seen in Appendix Q as compared to the scaled model solution illustrated next to the student sketch provided.

In analysing the first one in more detail, since no scale was included on the sketch, no further interpretation of its correctness according to the sketch could be ascertained from the rubric. However, the shape according to the cycle requirements was appropriate to that particular problem question, PROBLEM#4 in Appendix M. When the particular assessed file was opened it was found that the correct PV diagram shape was there, as seen by Graph 4.1 below.
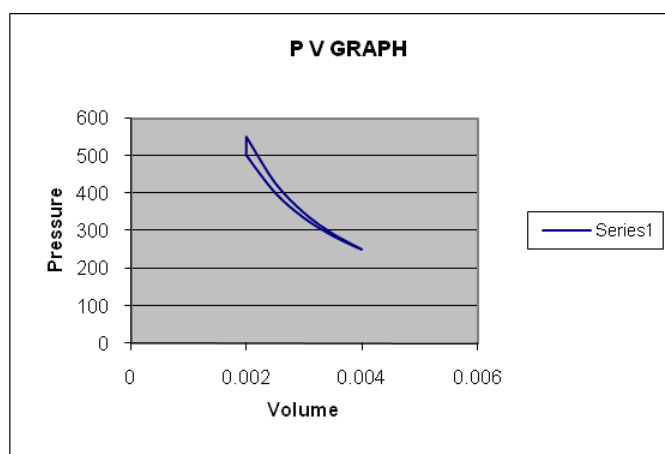
GRAPH 4.1 : Assessed student graph taken from Excel file

It was also noted that the graph illustrated was not calculated automatically, using the process formulas as it was supposed to, but that each point plot had been worked out manually and input into a table, as seen below in Table 4.5 below. However, the information used to draw the graph, in Table 4.5 was not as per the question given on the rubric, PROBLEM#4, seen in Appendix M.

Table 4.5 : Data used to draw Graph 4.5 above

Pressure	Volume
551.325	0.002
428.45	0.0025
348.678	0.003
292.937	0.0035
251.325	0.004
287.229	0.0035
335.1	0.003
402.12	0.0025
502.65	0.002
510.65	0.002
520.65	0.002
530.25	0.002
540.65	0.002
551.325	0.002

The graph is therefore incorrect although conceptually it has the same shape as the solution to PROBLEM#4, seen in Appendix N.

The second sketch in Appendix Q, relating to PROBLEM#2, could not be confirmed as to whether the diagram, although conceptually correct, was indeed a true correct answer. This was due to the files associated with it not being available from the backups, most likely due to lost files, one of the problems described in Chapter 4.1.1.

The fact that no graphs were correct was cause for concern. However, several factors could have contributed to this, such as:

▪ the file was not available to assess or was locked on the required day, one group reporting that the file was not locatable and three groups reporting locked files

▪ the graph was incorrectly displayed, twenty showing either partially or incorrectly formed graphs

▪ the graph was not in the spreadsheet at all, ten rubrics did not have graphs drawn on them at all and six groups specified that there was no graph in the spreadsheet

- incorrectly input or calculated values were used to draw the graph
- the graph was not automatically updated as new problems were entered into the spreadsheet, hence the original samples used as practice exercises were still generating the original practice graph (i.e. it was not dynamic).
- the exercise was too difficult or too long

Other reasons may also have applied, as indicated by some of the other comments students placed on the rubrics. However, there was no mark allocated to the graph itself, nor for the answer, as mentioned in Chapter 4.1.6. The comments the students made on the assessment forms, followed by staff assessor's comments, appear in Appendix J, as mentioned in Chapter 4.1.7.1. Although it was probably the first time students had assessed something, peer assessment or otherwise, some groups obviously interrogated the rubrics fairly carefully. One of the rubric's Likert Scale choices was associated with the graph, whether it appeared in the spreadsheet and if it updated itself in real time as new data was added, the only component that gave the graph a mark.. Reading through them, one can see that several student assessor groups commented on the graphs, their correctness, their inter-activeness (i.e. the ability to update itself when new information is presented to it), or simply the lack of one, as mentioned above.

In assessing some of the items in the other criteria students also referred to the keywords used in the rubric table in the 'valid evidence' column. This showed that they were at least attempting to consider key items in the spreadsheet assessments. This indicates that the assessment at least had face validity in that it attempts to assess items related to the outcomes for the subject. However, from a reliability concern if one compares the comments made by the students and the moderator (moderation is discussed in Chapter 4.1.7.3) the comments do not appear to reach consensus.

Moreover, during the assessment exercise it was observed that quite a number of groups were attempting to solve the problem themselves manually whilst trying to assess the spreadsheets. This was despite their being told that this was not required for the assessment exercise. The Researcher and his assistant had the solutions to all the problems with them, and students were told at the start that these could be viewed at any time to confirm the answers in the spreadsheet's solution. It was the spreadsheet itself that was supposed to be solving the problem. To the Researcher's knowledge, no students approached the Researcher or his assistant to check the answers during the assessment session. This may have been due to the

students not listening clearly to the instructions beforehand, but simply getting on with the task so that they could leave when finished, as many did not stay after assessing even though they still had plenty of time to work on assignment 2.

Again the problem that the assessor groups often had was to locate the files they needed to assess, because the server was continuously interrupted by viruses and kept hanging and had to be rebooted on several occasions, as described in Chapter 4.1.4. Students thus started to get restless during the exercise as much valuable time was wasted, some leaving as mentioned earlier. Some time was also devoted to running around trying to find the originators of the files to unlock them before they could be assessed. During this time it was also noted that some students were also running around trying to find their assessor groups. When questioned about this they said that they were "worried that the assessors were not going to assess them fairly". They were told to go and do the task allocated to them, i.e. assess the file they were supposed to. Just as Mindham (1998, p.50), as discussed in Chapter 2.6.2, mentions the inability of first time assessors to perform the task appropriately, it would appear that students don't appear to trust other students to do the task either.

Another problem arose when file names were not correctly recorded according to the instructions given on the rubric. The assessor group was instructed to save the assessed file with their assigned group code, together with the file extension ".ASS", as seen in Appendix E. Only nine appear to have done so on the assessment day. This problem could have been partly alleviated if the Researcher had written the file names required into the allocated area on the assessment rubric sheet beforehand.

4.1.7.3 Moderation

Eleven out of the thirty-nine peer assessed assignments were moderated. This represents 28,2%. Although the Researcher had originally indicated on the rubric that only 10% would be moderated, this would have totalled only 4 assignments, which would not have generated a large enough sample from which to obtain a valid moderation weighting factor.

The assignments to be moderated were specifically chosen after an initial evaluation by the Researcher of the returned rubrics, together with information provided by verbal feedback from the students on assessment day. The assignments chosen for moderation were those with very high or low marks and those where very diverse comments had been written on the rubrics.

As it was the students' first attempt at assessing their peers, if there was a large difference between the peer and moderator's assessment marks, then the final mark for that assignment became the average of the two marks. Guided by the DIT rule specifying that if a student's class mark is greater than 20% different to his exam mark (DIT, 2006, p.30) they are automatically eligible for a rewrite, a cut-off point of 25%, slightly higher than the DIT guideline, was chosen. This was done in order to achieve a more realistic and fair mark where groups may have been either too lenient or too strict in their marking, whilst still keeping the students' evaluation of their peers in the marking loop. This will be called the adjustment factor. This adjustment factor was used in seven of the eleven moderated assignments, two going up and five going down.

Besides the adjustment factor a moderation weighting factor was also calculated by dividing the average of the peer assessed marks by the average of the moderated marks. The factor obtained by this process was 0,9664, indicating that the peer assessed marks were generally slightly higher than the moderated marks. All the final Assignment 1 percentage marks were adjusted by multiplying them by this factor which lowered them slightly.

The justification for making both these adjustments can be seen by comparing the Ogive curves in Graph 4.2 of the peer assessed assignments before and after the moderation weighting factor and adjustment factor were used. The curve of the adjusted marks is closer to the characteristic S-shaped curve of a normal Ogive graph, ogiving being an accepted method of normalising marks.
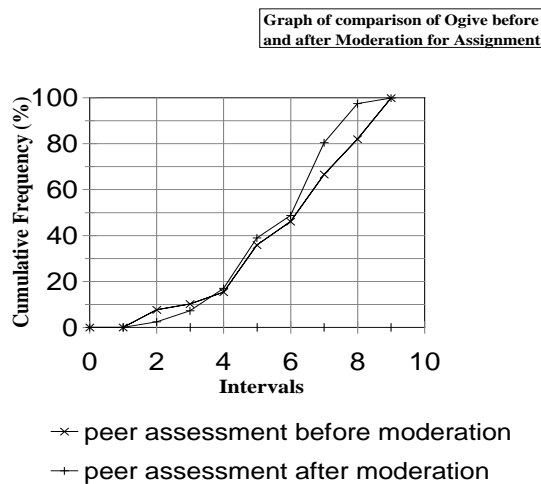
GRAPH 4.2: Graph of comparison of Ogive before and after moderation for Assignment 1

A further statistical analysis of the marks using Quattro Pro version 9 was also undertaken to evaluate the effect of the moderation exercise. Table 4.6(a) shows the statistical data of the students' marks before and after the factors have been applied.

Table 4.6(a):   Statistical Analysis of Moderation of Assignment 1

Statistical data	Students' generated marks	Moderator's mark	Marks after moderation weighting factor applied	Marks after moderation weighting factor and adjustment factor applied
Readings, n	39	11	39	39
Average, μ(%)	67,1	64,8	64,8	64,1
Population standard deviation, σ(%)	20,0		19,3	16,1
Sample standard deviation, σ(%)		16,2		

Walpole and Meyers (1978, p.513) indicate that in a standard normal distribution curve the following applies:

- 68,3% of the population should lie between the mean and plus/minus one standard deviation on either side of the mean,
- 95,4% of the population should lie between the mean and plus/minus two standard deviations on either side of the mean,
- 99,7% of the population should lie between the mean and plus/minus three standard deviations on either side of the mean.

Table 4.6(b) shows the predicted and actual numbers of groups that fall within these ranges and their respective percentages before and after the factors have been applied. From this table it can be deduced that including the moderation weighting factor alone did not change the distribution, as seen by comparing the middle two columns of the table. However, including the adjustment factor as well had a slightly bigger impact on the distribution, although it lowered the number in the first standard deviation interval, but brought the numbers in the second standard interval more in line with the expected value, the numbers in the third interval remaining the same throughout.

Table 4.6(b):   Predicted and actual numbers of groups in normal intervals

Normal intervals (predicted value in parentheses)	Number of groups after students' marking	Number of groups after moderation weighting factor	Number of groups after moderation weighting and adjustment factors
mean $\pm$ σ (68,3%)	26(66,7%)	26(66,7%)	25(64,1%)
mean $\pm$ 2σ (95,4%)	36(92,3%)	36(92,3%)	37(94,9%)
mean $\pm$ 3σ (99,7%)	39(100%)	39(100%)	39(100%)

4.1.8 Spreadsheet Assignment 2 - Non-flow and Steady-flow Energy Problems and Solutions

4.1.8.1 The assessment

The assessor teams were to assess their allocated file as a whole, using the assessment table seen in Appendix F, again graded on the Likert scale mentioned in 4.1.5. They also had to write down their comments in the spaces provided stating the assignment's good points and areas for improvement, as they had done for assessment 1.Only six rubrics of those assessed did not have written comments in the spaces provided. The comments received, reproduced verbatim from the rubric forms in Appendix K for each assessment form returned, varied widely.

Although the students appeared to understand the assessment process better by the time the second assignment was due to be assessed, most getting on with it quietly without having to query things continuously, it is the Researcher's opinion that most groups found the assessment a fairly difficult task, and gave up on it before the required time. Since the entire Assignment 2 mark counted only 5% towards the class mark as discussed previously in Chapter 3.8.3, or 2% towards the final mark, most students appeared to be happy to write it off as too hard to do for so little reward. This can be seen by the low attendance figures of the last two sessions seen in Table 4.3, sessions 6 and 7, and the numbers who completed the tasks, highlighted in Table 4.1, showing about a one third drop in number of students performing the tasks in sessions 6 and 7.

It is the opinion of the Researcher that generally the assessment tasks were not well understood. This was confirmed both in casual conversation with some of the students in the classroom after the first assessment session, and later when some comments, similar to "easier the second time

round", were made during the second assessment. Further reference to difficulties experienced with the computer exercises was mentioned during the interviews, discussed in section 4.4.3.1.1. These difficulties were not altogether unexpected as was mentioned earlier in Chapter 4.1.7.1 and Chapter 2.5.1.2, being first time peer assessors.

4.1.8.2 Analysis of the answers for Assignment 2

Of the assignment 2 assessment sheets that were handed in, only three answers were placed on the rubrics, none of which was correct. This could have been because of several reasons, such as:

- the file was not available to assess or locked on the required assessment day, nine groups reporting that the file was not locatable
- incorrectly calculated values were used to get the answer
- incorrect input or output of the data or formulas, seven groups indicating that there were incorrect formulas or missing parts in the formula or formulas didn't calculate anything
- simply not writing the answers in the space provided
- the exercise was too difficult.or too long

Considering the difficulty of the exercises, the following comments were made during the interviews, student H saying:

"Its more its its more of the programming, how to get your graphs right and it was...", and student D said :

"...After assignment one, maybe we fin, we find it easier to do assignment two, because we knew what eww we did in ah for the first assignment, and we know we knew our problems were were about...", and later

"...if I look at assignment two and then we looking back at us what we did in assignment one, what was our problems, we find it easier to do assignment two...".

In a meta-analysis study comparing the effects of types of learning skills interventions by Hattie, Biggs and Purdie (1996) they rated various interventions and came up with an "overall effect size" according to the type of intervention. Computer-assisted instruction was rated at 0,31, where "the typical effect size in educational interventions was 0.40" (Hattie, Biggs & Purdie, 1996, p.114). This indicates that computer-based instruction rates below the average.

However, part of this intervention included students' peer-evaluation of other students' assignments, which could be considered a type of remediation or reinforcement. In the Learning Strategies section of Hattie, Biggs and Purdie (1996), the Remediation/feedback was rated at 0,65, and Reinforcement, rated at 1,13, both above the average of 0,40.

When referring to the assessment of another groups work during the interviews, student D said:
> "...when we see do what is right, then you put in, plug in the values, ya did come up with the answer, so the students who ah did that assignment, they knew what they were doing. And then we learnt from them to do a a assignment two...".

Applying the same effect size calculation described in Hattie, Biggs and Purdie (1996, p.111), the Researcher came up with a figure of 0,13 for computer-assisted instruction which, although a positive figure, was considerably lower than 0,31 previously mentioned. One could interpret this as the style of intervention not being a significant contributor to the students learning in this study or that possibly the tasks were more difficult for the students than the Researcher anticipated, although the latter one is ambiguous without further comparison to other similar studies, or feedback from the students themselves. The interviews did reveal that the computer intervention was initially seen to be difficult by some students, as detailed later in Chapter 4.4.3.1.1.

4.1.8.3 The moderation

Of the twenty-one files assessed by peers, seven were remarked by the moderators, representing a 30% moderation load, again more than the 10% specified on the assignment form. Too small a sample would have been generated by the moderators using only 10%. Similarly to assignment 1, the averages of the peers and the moderators' averages were compared and a moderation weighting factor generated. This was 0,88821, a smaller figure than for assignment 1. Again, if the difference between the moderators' marks and the peers' marks was 25% or more, the average of the two marks became the final mark for the assessment. This occurred in only two instances, where one was under and one was over. The final analysis can be seen in Graph 4.3. As the sample size was significantly less than the first assignment, the graph begins to show an inability to become normalised as seen by the final graph shapes of both the pre- and post-moderated curves. However, the moderated mark begins to show a more normalised Ogive shape.
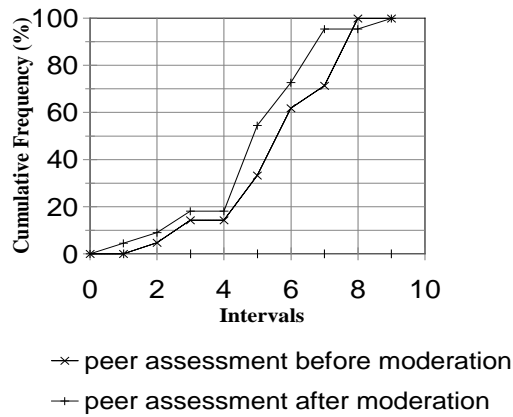
GRAPH 4.3: **Graph of comparison of Ogive before and after moderation for Assignment 2**.

A further statistical analysis of the marks using Quattro Pro version 9 was later undertaken to evaluate the moderation exercise. The results appear in Table 4.7(a) and (b) below.

Table 4.7(a): **Statistical analysis of moderation of Assignment 2**

Statistical data	Students' generated marks	Moderator's mark	Marks after moderation weighting factor applied	Marks after moderation weighting factor and adjustment factor applied
Readings, n	20	6	20	20
Average, μ(%)	65,3	62,0	58,0	57,6
Population standard deviation, σ(%)	17,0		15,1	14,8
Sample standard deviation, σ(%)		15,7		

Interpreting the data of Table 4.7(b), one can draw similar conclusions to those for assignment 1. The moderation weighting factor did not change the distribution in any way, while the adjustment factor had a bigger impact on the distribution. Reference to Walpole, and Meyers (1978, p.513) standard normal population distribution, detailed in 4.1.4.5, again applies.

Table 4.7(b):   **Predicted and actual numbers of groups in normal intervals**

Normal intervals	Number of groups after students marking	Number of groups after moderation weighting factor	Number of groups after moderation weighting and adjustment factors
Mean $\pm\sigma$	14(70%)	14(70%)	13(65%)
Mean $\pm 2\sigma$	19(95%)	19(95%)	19(95%)
Mean $\pm 3\sigma$	20(100%)	20(100%)	20(100%)

4.1.8.4 Reassessment of assignment 2

During a lecture soon after the end of the whole intervention, there was a request by various members of the class to redo assessment two as several things had gone wrong during that session. These included various computer related issues, mainly with the networked system, virus problems and so on, as previously discussed in 4.1.4. The Researcher agreed and a date was fixed for later in the semester for any group who wished to redo the task. This falls in line with the SAQA guidelines on assessment (South African Qualifications Authority, 2001, pp.53-54), where the same task can be performed again under the same conditions using the same instruments. Students were also allowed to work on the assignments in the meantime if they wished to improve their spreadsheets. Six groups went back later in the semester to redo the assessment of assignment 2. At the re-assessment each group had a rubric with a different problem from the original one, thus testing their spreadsheet on a fresh task, as recommended by the SAQA assessment guidelines (2001, p.54).

Again, each group member who signed the declaration on the assessment day declared that they would be allocated equal marks unless they specified otherwise. These re-assessment marks replaced the original ones and thus counted towards the final mark.

These new marks were added to the records overwriting their original marks, the same processes for moderation taking place in the same manner as previously discussed in Chapter 4.1.8.3.

4.2 The Study Habit Survey

Introduction

The study habit survey was handed out several weeks into the subject so that students could get settled into their normal studying routine first. It was distributed during session six, as seen in Table 4.3. The students were asked to fill it in there and then if they could, or to take it home and return it the following day. Since it was not a lengthy task, most students completed it that day, a few returning it over the next few days. Their data was then captured in a spreadsheet for later analysis.

The SPSS program was then used to assist in determining if there were any factors in the survey that may have influenced the marks significantly. As the primary goal was to determine what factors may influence success or failure in the subject, an extra variable was added, viz. the final subject mark of the students who participated in the survey, since this was readily available. Of the 96 who submitted the survey, only 65 final marks were available for use in the analysis. This was because 10 study habit surveys were submitted anonymously, the rest either failing the sub-minimum of 40% to write the examination (13 students), not finally registering (3 students), deregistering at some point (2 students), dropping out (2 students) or not writing the examination (1 student).

Factor Analysis was not a suitable method for this as most of the data collected was not "*continuous*" (Miller, Acton, Fullerton & Maltby, 2002, p.174), most of it being nominal or ordinal data (Miller et al., 2002, p.59). However, cross-tabulation, often "employed to examine the relationship between two variables (usually nominal or ordinal) that have a small number of categories" (Miller et al., 2002, p.127) was suitable since the sample sizes in each category were small. Some were too small to be statistically acceptable, SPSS requiring a minimum of five, and thus, although the outputs showed some significant trends, the analysis was inconclusive. The data recorded can thus only be considered as a snapshot of the student's study habits in this class and whilst it may be valid for these students it is probably not generalisable. Also the reliability of the results is low in many cases due to the low numbers in many of the samples.

The null hypothesis was that the variables, being the statements on the study habit survey (see Appendix H), had no influence on the success or failure of students, the parameter indicating this 2-sided significance being either the Pearson's Chi-Square, or if the sample was too small,

the Fisher's Exact Test. Only if either value was less than 0,05, a 95% confidence interval, would the variable indicate that it was an indicator of success and the null hypothesis would not be accepted. Because the number of counts in some cells was very small or zero, it was decided to merge some of the categories into simpler family members, thus increasing the counts in many instances and achieving a better result. Having done this, it was found that only one of these simpler groups became statistically significant, thereby negating the null hypothesis in this one instance. This case will be discussed in Chapter 4.2.4.

Since the study habit survey was divided into six categories, as discussed in Chapter 3.9, the analysis of the data will be discussed in each category. Although there was no statistical significance other than in the category mentioned above, some of the analysis did indicate some interesting results.

4.2.1 Personal Information

The components in this part were senior certificate symbols for Physical Science, Mathematics and English; English Language taken as a first or second language; ethnic group; parent/guardian highest qualification; repeating the course and personal objective.

As described in Chapter 3.9.1 students are accepted into the DIT based purely on a minimum symbol grade for Senior Certificate Physical Science and Mathematics. Some of the knowledge acquired in these subjects is used in this introductory subject of thermodynamics. The medium of instruction at DIT is English, hence a good understanding of English is also helpful, hence the requirement stated in Chapter 3.9.1. However, no statistically significant trend could be found for any of those three subjects when comparing the symbols obtained with their final thermodynamics result.

It was interesting to note however, that only 44,4% of English first language students passed, while 57,9% of English second language students passed. It was also interesting to note under ethnicity that 57,9% of the black students passed whereas only 38,5% of the other racial groups combined (whites, coloureds and Indians) passed.

Considering parents qualifications, the groups were simplified into grade 12 or less compared with more than grade 12 (assuming some form of tertiary education). The fathers' qualifications produced a Pearson Chi-Square of only 0,097, whereas the mothers' qualifications produced a

Pearson Chi-Square of 0,815. Although neither of these implies a statistical influence on the student's pass rate, it is interesting to note that the father's qualifications are over eight times more significant than the mother's qualifications. Considering a student's parent's or guardian's highest qualification, it was noted that the success rate for students, where both father and mother had lower qualifications, was higher than for those where both parents had higher qualifications. This could have been because poorly educated parents wanted their children to have a better quality of life, and saw education as the means to achieve this. Prior to Independence in 1994, poorly educated parents often came from certain ethnic groups who were disadvantaged because of the legacy left by the Apartheid era, whereby they were very often not able to obtain higher qualifications themselves. This was highlighted in the Cape Area Panel Study mentioned in Chapter 3.9.1 by Lam et al. (2010, p.11), where parental education can have an impact on student enrolment. Bhorat et al. (as cited in Cosser, & Letseka, c.2009, p.8) found, whilst looking into student retention and graduation that although "socio-economic variables are important in determining graduation and success in the labour market, they are not crucial:…other variables such as parental education were insignificant…". Whilst both of these studies considered student success (i.e. to graduate) a similar conclusion could be assumed here, that parent education is not a significant indicator of success in Thermodynamics II.

Concerning repeating students, in the sample analysed, 52,2% of students repeating the subject passed, compared with only 42,5% of non-repeating students passing. This falls in line with the general semester pattern, where the pass rate for Thermodynamics II is typically in the range 40% to 50%. Students were also requested to indicate what they would like to achieve for the subject. There was no significant relationship for either of the two variables, repeating and personal achievement.

4.2.2 Information Exchange

Information exchange was a category looking at means of communication. It was sub-divided into two components. The first was accessibility to computers outside the class lecture time, and the time spent on them. Since half the lecturing time was spent on learning the subject utilizing computers, it was felt that those who had access to computers outside of class may have stood a better chance of passing. The second area of communication considered was cell phones and their use, a mode of communication available to many students, and which can be a very powerful tool today as they can surf the internet like any other computer.

The final results showed no significant relationship between access to computers outside of class nor the amount of time spent accessing information on computers. Computer access realised a significance of 1,000 on a 2-sided Fisher's Exact Test (used since there were counts of less than five in the sample cells). Time spent was reduced to only two sub-divisions form the original four due to low sample numbers is each group. These became less than two hours and two hours or more. It did not yield a significant result. Thus, neither access to a computer outside of class nor amount of time spent accessing information on a computer was an indicator of increased chance of passing the subject. However, the Council On Higher Education report (2010, p.21) involving a sample of 13 636 students (35% from Science, Engineering and Technology) from seven South African institutions (comprising Universities, Comprehensive Universities and Universities of Technology (UoT) (formerly Technikons, of which the DIT was one)) the "majority of the sample (82%) indicated that their institution places significant emphasis on the use of IT in academic work and 84% of the sample indicated that their experience at the institution has contributed very much to their personal development in the area of using computers and IT".

Cell phones and their use were included here as 87% of the students surveyed owned one and spent time on it, sometimes even during lectures. A Pearson Chi-Square 2-sided produced a significance of 0,005, less than the 0,05 significance required. However, there were two categories with less than five samples, making this an unreliable factor and no Fisher's Exact Test significance was established. When the categories were reduced to only two and a Crosstabs analysis performed this revealed a 2-sided Pearson Chi-Square significance of 0,161, indicating that although the earlier result was less than 0,05 it was probably not reliable, as noted earlier. When looking at the use students made of this communication medium, namely chatting, MXit or web surfing, the sample sizes in each category were small and the results therefore unreliable. However, if one simply looks at the total numbers relating to this it was observed that between 50% and 70,8% of students using these communication styles of information exchange failed the subject. Whether there is a cause and effect relationship here is however, uncertain. The Researcher has observed students using their cell phones on many occasions during lecture time, including their use during the computer intervention classes, thus distracting them from the object of their lectures. Baron, Patterson, & Harris (2006, p.129) describe this as "perceived behavioural control" in which the user "reverses existing power differentials" by "texting…under the radar screen of their teachers" (Brier, 2004, p. 16, as cited in Baron, Patterson, & Harris, 2006, p.129). MXit, a modern way of keeping in touch and

socialising with friends, has had bad publicity and has become a cause for concern for parents, especially in relation to morals and ethics (Ross, 2008, p.8; Boomgaard, 2009, p.14). Cheating in examinations using cell phones, as mentioned in Chapter 3.9.2, is also on the increase, including at the DIT.

4.2.3 Library Use

This category was used to investigate whether the students had done the library orientation course, mentioned in Chapter 3.9.3, and to find out what use students made of the library. It was also investigated in the interviews and will be considered in Chapter 4.4.3.2.4. Approximately half indicated that they had done a library orientation course, but it played very little role in indicating success in the subject, giving a Pearson Chi-Square of 0,662. About half the students who had done it passed, and 44,4% who had not done it passed. A similar result was found when considering whether students had consulted a Librarian in the library. When the frequency of library use was analysed, it did not indicate a propensity for success. Even when the four 'frequencies of use' categories were narrowed down to two, there was still no significant relationship between library use and passing. However, it was observed that those who used the library more frequently had a slightly higher pass rate; 49,1% of frequent users passed versus 41,7% who used the library infrequently. This result, whilst relevant to this class is again not generalisable to the population. O'Brien & Symons (2007, p.414) found that "students were more likely to often or sometimes consult professors (77%) over librarians and the reference desk staff (65%)", but that they most commonly turned to their fellow students "(88%)" for information. They also found that science students were less likely to consult a librarian than other disciplines, as highlighted in Chapter 3.9.3.

Looking further students were asked to indicate what use they made of the library. Here again the sample sizes were generally very small, so no reliable result could be obtained. From the data acquired, it was clearly seen that students mostly used the library to find and use books rather than other reading matter. How effective the students are in finding relevant information, as discussed in Chapter 3.9.3 was not ascertained.

4.2.4 Subject Specifics

In this category, students were asked to indicate where they got their source material from to assist in enhancing their lecture notes. There were two primary sources, library notes and a recommended book as described in Chapters 2.2.2 and 3.9.4. Considering the analysis outcome

it was concluded that either source was equally likely to achieve success, neither one dominating, with about 50% passing from each chosen reference source. One could say that the library notes are adequate for the subject at a fraction of the cost of the text book. The use of text books was also brought up in the interviews and will be considered in Chapter 4.4.3.2.

The other part of this category was to find out how much time, outside of formal contact time, students dedicated to the subject per week. There were six times to choose from, namely four, three, two, one, none or 'other' hours. Analysing it according to these subdivisions did not produce any significant finding. However, when simplified into only two intervals viz. one to two hours and three to four hours, the output from this yielded a significant finding with a 2-sided Pearson Chi-Square of 0,027, as seen in Appendix Y.
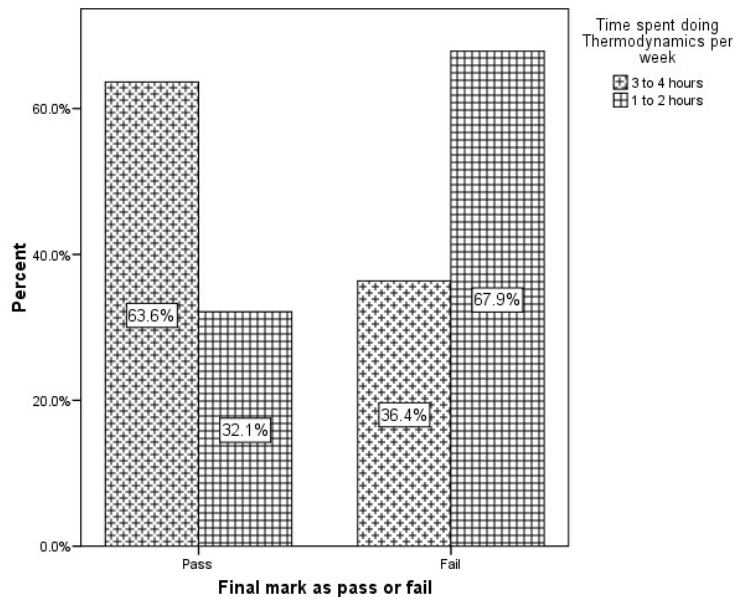
GRAPH 4.4: Time spent doing Thermodynamics per week

This was highly significant and the null hypothesis, that time spent outside of formal lecture time had no influence on success rate, was rejected. Of students who spent three to four hours per week outside of formal lecture time on thermodynamics, as recommended in their Learner Guide (Thurbon, 2006b, p.6), 63,6% passed, compared with those who spent two hours or less a week, where only 32,1% passed. Thus students who spend in excess of three hours per week self studying have twice the probability of passing as those who spend two hours or less. This is illustrated in Graph 4.4 above. The amount of study time, three hours minimum per week, also

falls within the range of time shown by studies at other universities, as reported in Chapter 3.9.4. In the Council On Higher Education report (2010, p.17) the average UoT student spent 10,7 hours per week preparing for class, slightly more than the overall average for all the institutions combined. Only one in four students studied more than twenty hours per week, whereas the report recommends that students should be spending 25-30 hours per week on preparation and studying, less than 10% actually doing this (ibid, p.18). This is slightly more than this research study finding if one assumes an average of five subjects, implying a minimum of fifteen to twenty hours per week. However, study times would vary depending on the programme and very likely the subject, this research study falling within the typical range, making the finding more reliable and valid.

4.2.5 Practical Experience/Exposure

In this section of the student study habit survey, students were asked if they had worked before entering the institution. They were also asked if they had been exposed to engineering, and if so which discipline or disciplines. Furthermore they were asked if they had been exposed to thermodynamics or associated thermodynamic equipment. It is also discussed in the interviews in Chapter 4.4.2.3.

Students doing the three year National Diploma in Mechanical Engineering at the DUT are required to do one year in-service training (now termed work-integrated learning, or WIL), in the appropriate mechanical engineering field, as part of the programme (DIT, 2006a, p.12) before they can graduate. They can do this component, broken into two six month components, at any point in their studies, although many students complete their university studies before entering for their WIL service. However, it can also be a stumbling block as they sometimes spend a lot of time trying to obtain the one year appropriate service, often extending their time to graduation. Pillay, & Wallis (2009, p. 71) in investigating dropouts and the reasons for dropping out found that 4,4% of respondents were not in fact drop outs but were engaged in work-integrated learning, something not always obvious within the Mechanical engineering department either, as students do not always follow correct procedure when starting their in-service training.

In analysing the data, firstly considering work of any nature did not produce any significant improvement in pass rates producing a Chi-Square score of 0,883. Secondly, there was very little difference in pass rates whether they had or had not worked, with only 44,4% of those who

had worked passing as compared with 46,4% of those who had not worked.

Exposure to specific engineering disciplines or thermodynamics and associated equipment, did not show any significant result either. Of those exposed to engineering disciplines 53,6% passed, a higher value than those who had not, at only 37,5%. Considering the type of engineering exposure, six of the eight cell counts were less than five, making any sort of interpretation unreliable. The only cell counts over five were those in mechanical, with 51,9% passing. Exposure specifically to thermodynamics related equipment yielded a 45,5% pass in those that had exposure compared with 50% who had none. Concerning the type of thermodynamic equipment, 66,7% of those exposed to boilers, a major component of the subject as seen in Appendix W (encompassing steam plant as well as the theory behind the sections of vapours, entropy and combustion), passed. The other two disciplines mentioned, refrigeration and air conditioning and engines, only achieved pass rates of 40% and 42,1% respectively.

Although this section did not show any significant trend in success rate it has been observed by the Researcher in the past that students who have completed one or both of their WIL training during their academic studies often come back into the classroom as more mature, self-motivated students harbouring a better work ethic than before they had done so. They are also more observant and willing to ask questions, specifically relating to the area of study at the time or to related equipment associated with the study area. This also falls in line with Kolb's experiential learning cycle, discussed in Chapter 2.1.5, of action and reflection whereby they can relate the current theory with experiences they had whilst in industry.

4.2.6 Study Techniques

Study techniques, as described in Chapter 3.9.6 was divided into six sub parts, preferred learning style, group work, rewriting notes, consulting learner guides, tutorials and test preparation. Each component will be considered in turn below. An extra component, not asked in the survey but the information became available during data gathering and added to this section was gender and is discussed at the end.

Firstly considering learning styles, the VARK classification of learning styles, as discussed in Chapter 2.1.4.1, was used to categorise them. A summary of the responses to the four learning styles, viz. visual, auditory, read/write and kinaesthetic appears in the Table 4.8 below.

Table 4.8: **Summary of Respondents Preferred Learning Styles**

Learning style	Percentage of respondents (%)
visual	49
auditory	6
read/write	31
kinaesthetic	14

It was noted that some respondents indicated more than one style and a few others ranked them, both options that were specified on the survey questionnaire. Looking at a summary of the styles in Table 4.8, it can be seen that visual learners were in the majority in the class, whilst auditory learners were clearly in the minority. In Felder and Brent's (2005, p.61) study summary by various researchers using Felder and Soloman's Index of Learning Styles (ILS) mentioned in Chapter 3.9.6, encompassing twelve institutions across various disciplines and study levels, they found that "82 percent of the undergraduates were visual learners, while most engineering instruction is overwhelmingly verbal, emphasizing written explanations and mathematical formulations of physical phenomena over demonstrations and visual illustrations". As lectures at the DUT are mostly verbal this indicates a potential mismatch between the style of presentation and the students preferred learning style.

It was also noted that no one chose auditory exclusively but only in combination with one or more of the other styles. All the other styles were either a single choice or combination with various other styles. Further, of the four styles, auditory was the only one that did not receive a response from the SPSS analysis, possibly because, either no one chose this type exclusively as mentioned above, or else no final examination mark was available for analysis with this style included and thus it was excluded from the count, since only fifty three of the total of ninety six participants, as seen in Table 4.1, were included by SPSS in this particular analysis. The other three styles together produced a 2-sided Pearson Chi-Square of 0,813, indicating no great significance or relationship to passing the subject. However these results are unreliable because two of the six cell counts for the three styles present were less than five, thus no further analysis could be made. However, considering the output from SPSS concerning learning styles it was interesting to note that visual learners were by far the majority of counts in the table, at 64%, and that they also obtained the highest pass rates, with 50% of visual learners passing, read/write style second at 43,8% and kinaesthetic third at 33,3%, although not a reliable result

for kinaesthetic in that only one individual count was present for a pass.

As much of thermodynamics involves the use of charts, graphs, diagrams and tables in order to get results, those inclined towards visual learning would be more likely to relate to the subject. This may explain the higher pass rate of visual learners in the study semester, while at the same time highlighting the mismatch between student learning and teaching methods. A reference to a visual learner is also touched on later in the interviews in Chapter 4.4.3.1.2.

As part of the study, students were requested to go to a learning style web site, and go through the exercise to determine their individual learning style. Only eight (12%) indicated that they had done so and of those, only four passed the subject. No further analysis could be done on this as no details were given, although it would have been of interest to know their learning style preferences as compared to what the study habit survey indicated.

Felder, & Silverman (1988, p.678) found in studying their students preferred learning styles, that "Active learners work well in groups; reflective learners work better by themselves or with at most one other person". Students were also asked if they worked in groups, and if so how often. Of the 57 valid entries in this category 72% indicated that they had worked in groups, but only 46,3% of those passed.

The next part of the survey considered if and how often students worked in groups. Although 75% indicated that they did work in groups, only 8% indicated that they did so often. Of the original four categories presented for frequency of group work, six of the eight cell counts were less than five, so the output was not reliable. It was therefore decided to reduce them to two, always/sometimes and seldom/never, thus giving more acceptable counts. When this was done, only one cell had a count of less than five. Although students are encouraged to work together, the output was somewhat disappointing, with only a 50% pass in the often/sometimes category, and a higher pass rate of 63,6% in the seldom/never category. Plant, Ericsson, Hill, & Asberg (2005, p.101), as mentioned in Chapter 3.9.6, indicate that working with others can cause unnecessary distractions thereby reducing the effectiveness or quality of the group studying. Having observed our students whilst studying in groups, the Researcher has noted that some members of the group are often causing a distraction by talking or shouting to others in the neighbourhood. Also a lot of students wear earplugs and are hooked into their cell phones listening to music, which can typically be heard by other members of the group. Both of these

can be highly distracting, reducing the probability of quality study.

The next component was rewriting of notes and how often. Only 25% of students indicated that they rewrote their notes. The rewriting of class notes was not a good indicator of success rate, with a 2-sided Pearson Chi-Square score of 0,414 Of those who did, 56,3% passed and 43,8% of those who did not, passed. Again, as the cell counts of the four original categories were low it was decided to re-evaluate them as two categories, namely weekly or less, and monthly or more. This then achieved a 2-sided Pearson Chi-Square of 0,833, an insignificant result, with those who did so more frequently achieving a slightly higher pass rate of 60% as compared with those who did so less frequently only achieving a pass rate of 56,3%.

The next statement involved the frequency with which students consulted their learner guide was also investigated under this category. The learner guide informs the students of all the requirements for the subject, as mentioned in Chapter 3.9.6. Although a good understanding of these would be helpful for students, it was not found to be a significant factor in determining success in the course, with a 2-sided Pearson Chi-Square of 0,469 after reducing the original five categories down to two, often/sometimes and seldom/never. The pass rates in the two categories was 42,5% and 52,9% respectively.

Another component investigated in this category was tutorials, both from an attendance perspective and how far the students take the tutorial questions. There are six tutorial handout sheets for the subject, one for each major section, with questions of varying difficulty as one works down the sheet. Firstly, tutorial attendance was considered. This was broken down into four categories originally but three of the eight cell counts were less than five, making analysis unreliable. It was regrouped into two categories regularly and sometimes/seldom/never. This realised a 2-sided Pearson Chi-Square of 0,464, indicating no significance. However, it was interesting to observe that those who attended regularly had a 51,6% pass rate and those who did not had only a 41,7% pass rate. Considering next how many of the tutorial questions on the sheet were attempted, the original five categories were simplified down to two, those who did all the questions and those who did some/tried them/if pushed, no student indicating that they never did any. This gave a 2-sided Pearson Chi-Square of 0,136, not a significant indicator, but lower than most others. When looking at the percentages, 60% of those who
did all their tutorial questions passed and only 39,5% of those who did some or attempted them passed, indicating a 50% greater probability of passing if they did all of them, as seen by Graph

4.5.
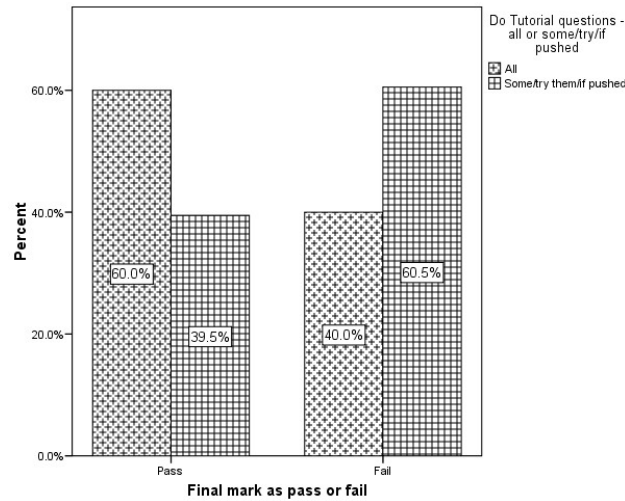
GRAPH 4.5:   Do all or some tutorial questions

The last component of this category was what students did the night before a test. The obvious one would be to get an early night, partying being a definite cause for concern, but, fortunately, no one chose this route. Again of the counts in the cells for the four choices, 50% were below the minimum of five, so it was regrouped into two, get an early night and all others. This did not, however, indicate any influence over the pass rate, with a 2-sided Pearson Chi-Square of 0,643. This was also indicated by the pass rates, 43,8% for get an early night and 50% for all others.

Another component that became available during the data gathering, but was not on the questionnaire, was gender, which was also tested to see if there was any significance to passing. Due to low numbers of females in the class the 2-sided Pearson Chi-Square could not be used. Instead a 2-sided Fisher's Exact Test was used, giving a significance of 0,479, indicating that gender was not significant. Looking at the pass rates of male to female, 50% of males passed and 33,3% of females passed. In a study including learning styles of students by Rosati (1993 and 1997) (as cited in Felder, & Brent, 2005, p.59), no significant difference was "found for academically strong male students or for female students". Also, Wise et al. (2004) (as cited in Felder, & Brent, 2005, p.66), in a study of two groups consisting of eight male and female students doing a first-year project-based engineering design course found no initial difference between the two groups. However, as they progressed through their studies a difference in the two group's intellectual development was noted. This type of change has also been noted by

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Belenky et al. (1997) and Baxter Magolda (1992) (ibid, p.67).

4.3 The concept test

Introduction

The concept test was a test designed to test the skills learnt by the students during their computer spreadsheet exercises on thermodynamics, as discussed in Chapter 3.10. The concepts would have to have been mastered to enable the correct completion of the two spreadsheet assignments described in Chapter 4.1. The fifth or final page of the Concept test, was an output result page, as seen in Appendix D Concept Test page5, giving the students immediate feedback as to how they scored overall and in each page, as described in Chapter 3.10. The programme specific and subject learning outcomes that this test covered were dealt with in detail in Chapter 3.8.3, as mentioned in Chapter 3.10.

It is noted that somehow one student managed to change the master file name about half to two-thirds of the way through the concept test exercise. This was surprising, as the master file was loaded on a remote server, stationed away from the laboratory, as described in Chapter 4.1.4. To further safeguard against this, the master file had been made a read only file, such that students had to access and open the file first, then were forced to change the name before saving the file. The read only format disallowed a direct save to the original file name, this being fairly common practice if one wants to keep the original file intact whilst at the same time using multiple copies of it. Thus students after 10h06, just over an hour into the exercise, had to find a new file named after a student's own student number. This was not the only problem encountered that day. Again the network system caused a lot of confusion, delay and frustration to students before the exercise could get underway, as mentioned previously in Chapter 4.1.4, with backdoor routes having to be set up first. However, most students managed to have an attempt at the concept test at some point during that session, and appeared to enjoy the challenge.

4.3.1 Overall summary of the test

Students were requested to save the file containing their score immediately after their first attempt. Although this was done in most cases, several students were seen attempting to improve their marks by going back over their answers. As this test was not for marks, no further attempt was made by the Researcher to ascertain whether the scores were from the first or other

attempt. The results published here therefore assume a first attempt result, although a few may not be so. A summary of the completed returns appears in the Table 4.9 below. There were 82 returns of the 120 registered students, representing 68,3% of the class.

4.3.2 The Choice of Sign Convention

The results analysis was available in either of two formats, since there are two different sign conventions popularly used by authors of thermodynamics and related books when considering the energy flow directions for heat and work. All thermodynamics books follow one convention or the other exclusively, the more popular sign convention in recent text books being that indicated for Eastop and McConkey (1993, p.xii) and seen in Table 4.9. Both have been taught and used by the Researcher and students and either is acceptable as long as one sticks rigidly to it. As there were two main sources of reference, mentioned in Chapter 2.2.2, each having a slightly different convention, as

Table 4.9:   **Summary of returns from the Concept Test**

			Additional notes and explanations
Number of completed returns		82	Number of completed returns by students, with 1 duplication
Sign convention used	Library notes	55	W_{out} and Q_{in} are positive W_{in} and Q_{out} are negative
	Eastop & McConkey	18	W_{in} and Q_{in} are positive W_{out} and Q_{out} are negative
	Both simultaneously	7	No conclusion can be drawn
	Non specified	2	No conclusion can be drawn
How many obtained 100%	Using Library notes sign convention	6	Some could have been a result of multiple tries
	Using Eastop & McConkey sign convention	0	
	Using both conventions simultaneously	1	No conclusion can be drawn

indicated in column 4 of Table 4.9, the spreadsheet had to allow for both and was built into the spreadsheets design and answer analysis from the start. The other convention as used in the library notes, is also used by Joel (1987, pp.15, 61-62), an author often consulted and

recommended for this subject, and a book previously prescribed for this subject, hence its use in the library notes.

The convention adopted was required to be indicated on page 1of the Concept Test spreadsheet before beginning the test (Appendix D: Concept Test Page 1). Thereafter all questions asked needed to be answered according to the convention specified by the student at the start. As seen in the Table 4.9 summary, the majority chose the Library notes convention. This was not unexpected since it was the more popular reference material as obtained from the study habit survey information and indicated by the pie chart, Chart 4.1, which indicates that 70,53% of the class had their own copy of the Library notes, whereas only 41,94% of students had their own book, as Chart 4.2 shows. Thus notes outnumbered text books by almost 2:1, although the text book indicated in Chart 4.2 was not necessarily Eastop and McConkey (1993).

Of those who had their own reference material about 30% had both notes and books. Seven people attempted to use both sign conventions simultaneously, an impossible task since the two conventions clash as seen in Table 4.9, and two students did not choose, making these nine results inconclusive, as indicated in Table 4.9. Seven students obtained 100% for the exercise, although one of these used both conventions simultaneously. How this student could have scored 100% is not understood, but it may have been a failure or limitation in

How many students have their own copy of the library notes

No (29.47%)—

—Yes (70.53%)

How many students have their own reference book

—Yes (41.94%)

No (58.06%)—
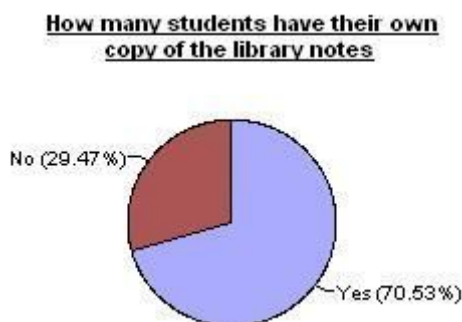
CHART 4.1:   Own library notes   **CHART 4.2:   Own reference book**
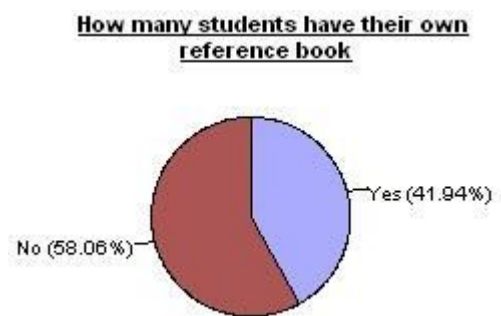
the logic behind the spreadsheet, which calculated the final results automatically, as incorrect information input may have confused the logic since no countermeasures were added to the logic to guard against this. It was interesting to note that those who chose to consider the Eastop and McConkey (1993) alternative did not get it all right although some did score high marks.

With such a small sample scoring 100% it would be difficult to draw any conclusions without further investigation, preferably via interview. This was not done, hence no further conclusions can be drawn. It is interesting to see that six students using the library notes convention got 100%, although some may have been repeated attempts, hence one cannot draw any further conclusions, suffice to say that the probability of achieving a top score would have been greater with the library notes since more students used them, as discussed earlier.

4.3.3 Summary of Page Analysis

Of the 82 completed returns, a page by page breakdown of the average percentage results for each page, based on the sign convention used, is seen in Table 4.10 below.

Table 4.10: **Summary of Page breakdown of the Concept Test**

AVERAGE PERCENTAGE SCORES OBTAINED		
Page	Library notes Sign Convention	Eastop & McConkey Sign Convention
1	46	41
2	52	50
3	85	83
4	77	75
overall average score	71	68

Considering the average scores obtained for the Concept Test, seen in Table 4.10 above, it can be seen that the average scores for each page, separated by sign convention/reference source, are very similar in value, being only between two and five percent different for the different sign conventions/reference source. It is noted that overall the library notes convention scored slightly higher in each section, including the overall average test score. This could have been due to the fact that this convention was used by the lecturer in class illustrations, since he was more familiar with it, having used it for many years prior to this. The alternative one only appeared in Eastop and McConkey's latest edition, from 1993 onwards, this book only being recommended for this subject from around 2000 onwards.

Shortly after this Concept Test had been presented to students, feedback was solicited from them in the next lecture session as to how they found it. There was quite a positive response, since it gave them a quick test on their knowledge gained, and also gave them immediate

feedback as to how well they had done on the summary page in the file itself (Appendix D: Concept Test Page 5), together with a breakdown of how well they did in each page. An analysis of each page's results, using Quattro Pro Version 12, appears in the sections that follow.

4.3.3.1 Analysis of page 1 answers

Page 1 tested the students' knowledge on processes and graph analysis, energy types, flows and direction involved in the processes, and their knowledge and understanding of the application of the first law of thermodynamics. All this knowledge was required in the generation of the Assignment 1 spreadsheet and is fundamental for nearly all problem-solving in thermodynamics. It can also be cross-referenced to the subject learning outcomes described in Chapter 3.8.3 and seen in Appendix W.

Considering Graph 4.6 it can be seen that more students using the library notes sign convention got all their answers right (25%) compared to the students who used the Eastop and McConkey sign convention (6%). Theoretically either convention should have an equal chance of success. This may again have been because they learnt one convention in class, the Library Notes one, and then used the text book without having taken note of the change, although this change had been pointed out to them, and emphasised in class regularly. However, the roles are almost reversed for the four out of five correct. The rest of the numbers of questions correct (3 to 0 correct out of 5) had a similar result for both sign conventions.

GRAPH 4.6:   Summary of page 1 answers

A further breakdown of each question revealed the following result, seen in the Table 4.11

below.

Table 4.11:   Results of page 1

Question	Number of correct answers	Notes sign convention (%)	Eastop and McConkey sign convention (%)
A	2 correct	31	28
	1 correct	18	39
	0 correct	51	33
B	1 correct	69	56
	0 correct	31	44
C	2 correct	29	11
	1 correct	22	33
	0 correct	49	56

<u>Note</u>: Questions (a) and (c) both had two correct answers and both should have been quoted

Looking more closely at the results in Table 4.11 above, it can be seen that less than a third of the students got the whole of question (a) correct, and less than half got it partly right using the notes sign convention. Two-thirds of the other convention users got it at least half correct. To obtain the two correct answers for part (a) required the use of basic deductive thermodynamic logic, as defined by particular learning outcomes under 'Introduction-basic concepts' and seen in Appendix W. Analysing the two required answers to question (a) further, for the first part considering purely the work energy flow direction in a compression process, 42% of students using the library notes sign convention used the convention correctly (i.e. <0), whereas only 33% using the other sign convention did so (i.e. >0). The second part to question (a) involved choosing the correct adiabatic equation for work during a compression process, also detailed in the 'Introduction-basic concepts' and seen in Appendix W. Here only 38% of library notes users chose the correct equation, whereas 61% using the other convention chose correctly. This is quite a significant difference. Thus, although some students may recognise the correct energy direction, it appears that they may not be able to apply it in the required manner by choosing the correct equation. It would be difficult to deduce anything further without questioning the students as to why they chose those answers.

The responses to question (b) required an understanding of the term "adiabatic", the process defined in the question statement. This term implies "no heat energy transfer to or from the

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process", requiring the same response for either sign convention used. Over half the respondents chose the correct answer using either sign convention (69% for the notes sign convention and 56% for the books sign convention), but at least a third got it incorrect. This is a term often misunderstood and used inappropriately in thermodynamics.

For the third question, question (c), there were again two correct answers. To answer this question successfully students needed to use both the adopted sign convention and the first law of thermodynamics at the same time for the first answer. To get the second answer correct, students needed to recognise the appropriate equation for the adiabatic process, and then substitute into the First Law equation. As seen in Table 4.11, only 29% using the notes sign convention and 11% using the books sign convention chose both answers correctly, 22% and 33% respectively choosing one answer correct only. Of those who answered the energy flow direction correctly, 47% using the notes convention and 39% using the books sign convention answered correctly. Of those who answered the equation correctly, 33% using the notes convention and only 17% using the books sign convention answered correctly.

A study by Meltzer (2004a, pp.1440-1441) on students in an introductory physics course also used a P-V diagram to investigate students' responses to a problem and was similar to the problem posed in this study. In Meltzer's study students using the diagram were required to consider the work done, the heat transfer and the change in internal energy, questions **a**, **b** and **c** in this study. He reported that correct responses to the heat transfer ranged from 40% to 56% in the written test (ibid, 2004a, p.1436) but only 34% of the interview subjects (ibid, 2004a, p.1434). He also stated that only a "31% success rate ...were able to make any practical use of the first law of thermodynamics" and further that only "one in five students in our samples emerged from the introductory course with an adequate grasp of the First Law of Thermodynamics" (ibid, 2004a, p.1441). In another study by Loverude, Kautz and Heron (2002, p.140), using the same adiabatic compression process as the Researcher used, only between 20% and 25% of students recognised the relevance of the First Law of Thermodynamics, even after being prompted with it. Thus, the Researcher's results are similar to those of other studies done, the only difference being the Researcher's students were doing engineering and in the other studies, students were from other disciplines, but were essentially analysing the same type of problems using the same laws of thermodynamics. The correct responses from students were generally slightly higher in the Researcher's study than in the other studies. However, the Researcher's students were not asked to justify their responses with further explanations,

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whereas in both other studies students were asked to justify their chosen answers.

4.3.3.2 Analysis of Page 2 Answers

Page 2 tested the students' knowledge on cycles, which are 'a number of processes following each other sequentially, to form a closed loop'. Questions on this page also tested graph analysis. This involved visually integrating the energy types and flow directions involved in the cycle and interpreting the graph as a whole. The questions also tested the students' knowledge and understanding of the first law of thermodynamics. These concepts were all required in the generation of the Assignment 1 spreadsheet, and are fundamental for nearly all problem-solving in thermodynamics. They would also involve components of the learning outcomes as specified in the 'Introduction – basic concepts', seen in Appendix W, mentioned previously.

If one looks at the results achieved, summarised in Graph 4.7, they were similar for both sign conventions, neither one scoring high on three correct answers. The similarity in the results was expected, since the answers were based more on a combination of the first law of thermodynamics and thermodynamic cycle's convention logic. The sign convention adopted was less predominant and

GRAPH 4.7:   Summary of page 2 answers

will be discussed further in the detailed breakdown below. A further breakdown of each question revealed the following result, seen in Table 4.12 below.

Considering each question individually, question (a) required students simply to consider the cycle direction (clockwise in this case), to determine that the net work done is out of the system. A positive answer was obtained using the notes sign convention, and a negative answer for the

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book sign convention. Neither convention dominated here with both conventions obtaining a 56% correct answer from the students.

Table 4.12:   Results of page 2

Question	Number of correct answers	Notes sign convention (%)	Eastop and McConkey sign convention (%)
A	1 correct	56	56
	0 correct	44	44
b	1 correct	24	22
	0 correct	76	78
c	1 correct	51	56
	0 correct	49	44

Question (b) was conceptually more difficult to answer, in that the quantities of heat energy required for each process would have to be envisaged, and their magnitudes considered, the net result of all three processes yielding a positive answer for both sign conventions. Here the students performed poorly using either sign convention, leading to very few with three correct answers, as illustrated in the summary Graph 4.7 pertaining to the results from this page. This was surprising, but no further explanation from students as to why they chose this answer was requested, as compared with the other studies mentioned previously in Chapter 4.3.3.1. However, further analysis of the answers chosen for that question revealed the following result indicated in Table 4.13.

Table 4.13:   Percentage of students who chose heat transfer answers incorrectly

Answer chosen	Notes sign convention (%)	Eastop and McConkey sign convention (%)
Q = 0	20	44
Q < 0	49	33

Table 4.13 shows that quite a number of students incorrectly chose either net heat of zero, Q = 0, or that there was a net heat output, Q < 0. This question was answered incorrectly by 69% of students using the notes sign convention, and 77% chose incorrectly using the book's sign convention. These figures are slightly higher than a study by Meltzer (2004a, p.1436) where

between 40% and 60% of students gave incorrect responses for the quantities of heat involved in the processes presented to them. In the studies by both Meltzer (2004a) and Loverude, Kautz and Heron (2002) they delve into the difficulties encountered by students in applying the concepts of heat and work, differentiating between them, and being able to analyse thermodynamic problems relating to them. A misconception also reported in these studies, is the difficulties students had in distinguishing between work, heat and internal energy, which are all different forms of energy. This has also been picked up by the Researcher when interacting with students. A further misconception is the difference between heat and temperature which is also reported by Loverude, Kautz and Heron (2002, p.142).

Question (c) considered the change in internal energy associated with the cycle. Since a cycle, by definition, returns to the original starting point, the start and finish state points are the same (point "a" as seen in the diagram in Appendix D: Concept Test page 2) and thus the net change in internal energy is zero. Here the concept of internal energy, U, as a state function is important, and also that returning to the same state point means that the internal energy of the substance returns to the same level. Here again the use of the first law of thermodynamics needs to be understood and used in the analysis. As can be seen from Table 4.12, for question (c), just over half of the students answered correctly for both sign conventions, neither one dominating. In the study by Meltzer (2004a, p.1436) 85% gave the correct answer to a similar problem whereby there was no net change of internal energy in the cyclic process described.

4.3.3.3 Analysis of page 3 answers

Page 3 tested the students' knowledge of the recognition of the components of a closed system, the terms and energies involved. This was conceptually an easier task, which can clearly be seen in the results achieved as summarised in Graph 4.7. Again an understanding of all these terms was required in the generation of Assignment 1, which was based on a closed thermodynamic system, and is fundamental to problem solving in thermodynamics.

Considering the summarised results in Graph 4.8 for Page 3, the sign convention had no influence on the required answers. The summary therefore indicated fairly similar results for both references, nearly half getting the entire set correct, since it was based more on the recognition of terms associated with closed systems, as seen in the notes or thermodynamic text books, rather than deductive logic. Combining both reference answers together, 92% of the students chose the locations of heat and work correctly on the diagram, with between 4% and 5% of students incorrectly choosing heat for work and vice versa. The Researcher has often observed students substituting one for the other, as well as using their symbols incorrectly, using Q for W and vice versa when they apply heat and work to calculations. This was also observed by Meltzer (2004a, p.1437) and Loverude, Kautz and Heron (2002, p.142).

GRAPH 4.8:   Summary of page 3 answers

4.3.3.4 Analysis of page 4 answers

Page 4 tested the students' knowledge of open systems, the terms and energies involved. This again was conceptually an easier task, which can clearly be seen in the results achieved as summarised in Graph 4.9. An understanding of all these terms was required in the generation of Assignment 2 spreadsheet and is fundamental for nearly all problem-solving in thermodynamics, as systems are typically analysed as either a closed system (as in Page 3 answers), or else they are open systems as in Page 4 questions.

Considering the summarised results in Graph 4.9 for Page 4, the sign convention again had no relevance to the required answers. The summary, therefore, indicated fairly similar results for both references, over 50% getting the entire set correct, since it was based more on the recognition of terms associated with open systems, seen in the notes or books, rather than deductive logic. A similar observation could be made here to what was said about the closed system in Chapter 4.3.3.3, when it comes to substituting the correct form of energy into the

appropriate equation, specifically so with heat and work. Combining the results of both conventions together, between 89% and 92% gave the correct answers, and between 3% and 8% gave incorrect answers for the heat and work locations on the diagram. Hence the students chose the correct locations less in this task, and incorrect choices were slightly higher than in the closed system of Page 3 answers in Chapter 4.3.3.3. A similar comment could be made, as in section Chapter 4.3.3.3, about the incorrect use of the symbols by students in worked examples especially as considering the heat (Q) and work (W) terms. This again ties in with the observations of the other researchers mentioned previously in 4.3.3.3.

GRAPH 4.9:   Summary of page 4 answers

4.4 The Personal Interviews

Introduction

The interviews were of a qualitative nature as mentioned in Chapter 3.2.3 and discussed in Chapter 3.11, so their analysis falls within an Interpretivist Paradigm and will be analysed as such. As the format of the interviews was semi-structured, described in Chapter 3.11, using the interview guide as described in Chapter 3.11.2, this helped to focus and guide the process whereby common topics of interest were covered in each interview. At the same time it allowed students a certain amount of freedom to deviate from the questions into areas that may have held a particular importance to them personally.

Even though every attempt was made to translate the taped data exactly, there were some areas which could not be heard clearly enough for translation, and would therefore be open to some interpretation. Fortunately this did not amount to very much of the total time of the interviews, although much time was spent on trying to decipher the words such that they were a correct

translation of what the student said.

As was discussed in Chapter 3.11 the Researcher brings his own view of reality into the equation. When one has to interpret information given in interviews one is often at a loss as to where to start, how literally to interpret the data, and how much emphasis one should place on the interpretation of the information presented by the interviewees. In setting about this task, it was decided from the beginning that a fairly literal interpretation would be done, using a bottom up approach (Rule, 2007) to generate themes and keywords.

Various tools that are available to use in analysing the transcriptions were mentioned in Chapter 3.11.3. Although other programs were available and possibly would have been better, Transana was chosen to do this job as a trial on its use. When listening to and compiling the interviews, seven themes were generated in Transana, known as "Collections", the first step of the process as mentioned in Chapter 3.11.3. These themes are highlighted in Appendix R, together with a brief synopsis of each theme.

Next key words or phrases were noted and positioned within each theme or collection. Some of the items discussed in the interviews, related to more than one keyword or phrase, and were duplicated in the themes. An explanation of each keyword's context, within each theme, is provided in Appendix S. The majority of the keywords and phrases were the words students actually said although some were those that one could use to describe a condition or situation. Information relevant to the study questions, mainly the primary and sub-questions one and two, introduced in Chapter 2 and included in Table 3.1, will be used as a basis for the analysis of this section. Some of the information expressed was outside the study question's scope mentioned above, although some of it was pertinent to other study intervention components such as the student study habit survey and will also be included in this section.

4.4.1 The Choice of Students for the Interview

The choice of students chosen for the interviews, by purposeful sampling, was initially as indicated in Chapter 3.11.1. Nine primary students were issued with the letter mentioned in Chapter 3.11.1 and seen in Appendix X. To obtain as broad a spectrum as possible, besides the class mark criteria, students were also chosen taking into consideration both gender and race. All of the nine students replied that they were prepared to be interviewed, and meetings were

thus set up. However, several of them did not appear for these interviews, and when approached later declined the invitation. A further seven students, prepared on a backup list mentioned in Chapter 3.11.1, were approached, but most of those students declined. More students were then approached but on a more accidental sample (Fink, & Kosecoff, 1985, p.59) basis, as the semester was coming to an end and students were getting ready to leave soon after their last examination had been written. The Researcher still managed to interview students with a fairly broad spectrum of marks, although not as wide as originally hoped for, all of them having gained a class mark of 40% subminimum. Gender was not as widespread as originally planned, with only one female student interviewed. However, although males tend to far outnumber females in all engineering disciplines, the nature of the subject is not gender specific so the sample was probably fairly representative from that aspect. Unfortunately more than half of those interviewed were repeating the subject, a problem not initially catered for, and not picked up before or sometimes even during the interview due to the final nature of the sampling strategy mentioned above. This was an oversight on the part of the Researcher, as he was hoping for all first time students. A brief summary of the students interviewed appears in Table 4.14 below. They represent 8% of the class as seen in Table 4.1. As seen in Table 4.14, six students finally passed the subject (67%), higher than the overall pass rate of 52%.

Table 4.14:   Summary of students interviewed

Student	Gender	Race	Class Mark (i.e. 40%+)	Wrote Exam	Passed/Failed Subject	Repeat
A	M	W	Y	N	F	
B	M	B	Y	Y	P	R
C	M	C	Y	Y	P	
D	M	B	Y	Y	P	R
E	Fe	I	Y	Y	F	
F	M	W	Y	Y	F	R
G	M	B	Y	Y	P	
H	M	B	Y	Y	P	R
I	M	B	Y	Y	P	R

Note: M=Male, Fe=Female, W=White, B=Black, C=Coloured, I=Indian, Y=Yes, N=No,
          P=Pass, F=Failed, R=Repeat

4.4.2 How do students learn thermodynamics

This was **sub- question 1** of the Thesis, as seen above Chapter 2.3.1, and in Table 3.1. It was also investigated in the Student Study Habit Survey, discussed in Chapter 4.2.4 and 4.2.6. However, as mentioned above, only the relevant parts of the interview will be analysed here.

4.4.2.1 Group work versus individual study

The advantages of group work as a method of learning, which can teach one cooperation and teamwork, was introduced in Chapter 2.2.6 and the method used in the computer intervention. It is also how the practicals are performed, mostly with teams of three students.

Although there were only nine students interviewed there were a variety of different methods used by students to approaching the studying and learning of this subject. Seven of the interviewees said that they study on their own (A, B, C, E, F, G, H), although some suggested that studying in groups, whether with friends or acquaintances with a common purpose, was probably a good idea, student B suggesting that:

> "...I've mentioned that I actually study alone eh when I do my work but then I think the group work is the best eh way to actually study, because you you get eh different people who can actually explain that a kind of section that you maybe you don't understand in a better way compared to the lecturer...".

Only two students (D and I) (22% of the interviewees) indicated that they regularly study with a group. This is in contrast to the study habit survey in which 75% of students indicated that they had worked in groups, as seen in Chapter 4.2.6, many possibly indicating the computer intervention, although only 8% indicated that they did so regularly.

4.4.2.2 Consult fellow students or the lecturer

The response to this particular question was somewhat surprising but not altogether unexpected. In the Council On Higher Education report (2010, p.18) it was found that "students at the universities of technology reported significantly higher levels of participation in active and collaborative learning than all the other institutional types", and concerning collaborative learning experiences it was reported that seniors regularly tutored other students (ibid, p.19). It also found that "only 16% of students often discuss ideas from class with their lecturers outside of class". Also, O'Brien & Symons (2007, p.414), as mentioned earlier in Chapter 4.2.3, found that students more often consult their fellow students than anyone else.

Although the Lecturer makes himself accessible to students as much as possible, both in and out of lectures, as suggested by student C when he said:

> "...I managed to get to you, I think you know I've been bothering you since day one, Sir.".

the information revealed on this topic, when it arose, was interesting. Although some students consulted the lecturer directly, both during formal sessions and outside, many of the students followed the route of consulting their friends first, mentioned above, then others in the class who could possibly help them and lastly consulting the lecturer. Some said that they had never consulted a lecturer, in this subject or even in other subjects. One student, D, suggested that rather than having formal tutors:

> "...but then for tutors, maybe you won't understand that guy, then you'll find it difficult to understand that section, but if you know of friends outside...",

he would rather seek friends who had passed Thermodynamics II and were now at a higher level, because:

> "it is easy to approach them, you know them, so where we tend to have friends who who doing, have you, who are in the higher level than us...so you interact with your fellow students".

One student in particular, C, had a very methodical approach to questions concerning the subject and how he approached the Lecturer, stated that the initial step was:

> "...sitting down with a text book and reading and...",

then he would:

> "...consult other students that I know may have an understanding of the sa of the section I'm working on...",

and finally:

> " if still there is no solution, then I'd consult a lecturer".

Even when consulting a Lecturer, student C had a very methodical approach, where he would consult the lecturer first to get the method, and then try it, consult a second time to see where he went wrong, and finally to see a worked solution if he was unable to work out the solution.

4.4.2.3 Practical exposure

Kuh (2010, para.2) reports that in a "2008 National Survey of Student Engagement show that working is positively related to several dimensions of student engagement, especially for full-

time students". If done appropriately he suggests that it helps students to integrate their class learning with "other life experiences" and that students can "see firsthand the practical value of their classroom learning by applying it in real-life settings", and it can even help "clarify their career aspirations" (ibid, para.4).

Some of the interviewed students had either worked in industry or had been on a plant with thermodynamic-related equipment on site. This, they said, had helped them to relate to the subject better. As Student C said:

> "There's a section that dealt with steam plant Sir. Personally I have seen factories but I've never really understood what was happening in some of them. I have seen steam coming out of factories. So now I have a little understanding as to what really happens in plant due to having studied Thermodynamics II, which had a section on on steam plant..."

and:

> "...The combustion as well, which which which dealt with the combustion of fuels, because I had done the course on Motor Vehicles I, which dealt with motor vehicle engines which use compression ignition engines and so I gained a little more insight as to what really happens in an engine when you are burning a fuel, due to studying".

Student F, who had been doing some of his Experiential Training (now termed Work Integrated Learning (WIL)), which all students have to do as part of their Diploma (Durban Institute of Technology, 2006a, p.12), and which lasts a year, said:

> "Well, I worked at I worked at xxxxxx Mill...and I mean there it's just that is all it is, is thermos and fluids, so you just use everything from boilers, diffusers, economisers...When I when I did my course, when I did my I was not an EIT obviously but I was a like a trainee there for a month in July and they they do a evaluation on everyone...and they had to evaluate me and they said I had a great understanding of thermos meanwhile I knew I didn't really have the best knowledge of what was going on, so ya you can apply it there perfectly."

He then went on to say:

> "Well definitely, if I continued there and became an EIT or whatever, at ... it would be of massive use. It would it's everything you do is thermos".

As introduced in Chapter 2.4.1, the problem of lack of exposure to any industrial equipment or

environment, aggravated by lack of resources in rural areas especially, continues to be a problem. The Researcher has experienced this type of problem many times, especially when it comes to the practicals in the laboratories, where students have no idea what the equipment looks like let alone how it is functioning.

4.4.2.4 Motivation

One of the major problems that one comes across with this subject is that students do not see it in context or how to apply it. Because of this they do not see a need for the subject, initially anyway. This leads to a lack of motivation, an area discussed in Chapter 2.1.6, especially at the start, where the basics are learnt. As with many new subjects, the first part requires the student to learn the subject itself, the terms, rules and so on that one needs to be familiar with, the dictionary of the subject if you like, an important area highlighted in Chapter 2.3.2. If one fails to grasp those basics at the beginning, the rest of the subject and its associated following subjects, become one battle after another. However, like reading a dictionary, it soon becomes boring, and this carries on as a trend. It is only later, when the more practical components are dealt with utilising the terminology that students start to take an interest. This is generally in the second half of the semester, after the computer assisted learning intervention was over, and they were into the more conventional lecture style. Student A, who battled from the start, said:

> "the beginning was it was a bit rocky, um, things started going terribly wrong from there so that totally demotivated me for the rest of the the the time. I'm only now really starting to get to grips with bits and pieces but, hopefully its not a a little too late, but um very confusing in the beginning..."

Although the Researcher had several one-on-one interactions with both this student and his group during the computer laboratory sessions, as the student said above, the motivation to carry on trying just was not there from the start. This student only appeared to get motivated toward the end of the semester when lectures had finished, coming to ask the Researcher about several problems he was having with various sections. This sudden motivation is noted when he says, during his interview:

> ...since I started more or less understanding what its all about, I'm very curious now which I don't really experience with any of my other subjects..."

and:

> "...so I would take my book and I would kind of read just to, just cause it looks like a very interesting field now".

However, a little too late and even though he qualified to write the end of semester examination he decided not write it, subsequently going on to redo it later and passing, thereafter carrying on with both the follow-on subjects, passing both. Perhaps the Researcher is also to blame by not providing more support when required.

4.4.2.5 Deep and surface approach to learning

As with many engineering subjects, time is always tight and students will often only start studying when they have to cram just before a test. There were a few however, who realised the importance of studying early and looked for the meaning behind what the lecturer said. Student C, who had a deep learning approach to the subject, introduced in Chapter 2.1.2, said:

> "Due to understanding the first section it has enabled me to grasp the the the latter sections quicker because the first few sections were actually the basis of the work done in the latter latter sections".

In contrast, Student F, who had a surface learning approach, introduced in Chapter 2.1.2, stated that:

> "People are would much rather learn the understanding of it than parrot learn it, but I would much rather learn it parrot fashion than than try and understand it, because I do not know what's going on. I try. I can sit there and ah in a lecture and I just – well half of us, I know, we don't get what's going on, we really don't get the the the deeper meaning of it and the questions that we get asked are the deeper, they're not shallow, on the top questions. Then it would be easy."

and said of the first part of the subject:

> "Especially cause its Thermos you it's the first Thermos course so you learning the basics from the beginning. Thats the basi.., thats what you need to pick up straight away".

Whilst querying the checking of past paper answers, one student was being asked how they determined if they knew if their answer was correct. The reply was that the question may have been the same as a tutorial or a past test. The Researcher then asked "Well, how would you know that you've got the right answer. You may have a solution that you've done...", to which the student added:

> "Or that you've learnt.".

This could obviously be interpreted in several ways, one being that students will go and find the

solutions to as many past test papers as they can, and simply learn how to write out the answers if that question, or something very similar comes up, clearly a very shallow approach to learning. The lecturer is well aware of this method, and usually takes steps to anticipate or avoid this problem. The Researcher has observed this much more frequently in the last several years, whereby students gather as many solutions to problems as they can in the hope that one learnt will come up. Scott and O'Connell (2000, pp.1-2) in describing the requirements of students to achieve in thermodynamics "requires knowing the fundamental principles and using procedures that are abstract and mathematical. Next, teaching styles and structures based on problem-solving methodologies or on deductive reasoning can require students to discover for the first time a need for strategies of learning that are more sophisticated than what is their usual previous experience of memorization and working of many example problems without generalization". Discovering all of these requirements at one time, abstract thinking, deductive reasoning and deeper levels of learning, together with all the others demands placed on students can be overwhelming leading to brain overload as Sweller (1988, as cited in Kirschner, Sweller and Clark, 2006, p.77) suggests, highlighted in Chapter 2.2.5. Staying self motivated with all these things going on could be difficult.

4.4.3 Student problems experienced whilst studying thermodynamics

This was one of the questions posed in the interview, question 4 as seen in Appendix I. Key words and phrases were picked out from the students' answers, forty-four in all, although some answers overlapped with each other. Some of the areas discussed crossed over themes as mentioned previously in Chapter 4.4. This component of the interview relates directly to **sub-question 2,** seen above Chapter 2.4.1 and in Table 3.1. There were various problems experienced, which one could probably sub-divide into categories in numerous ways. The Researcher has chosen to divide them into two main groups, associated with academic and non-academic issues, further expanded upon in the following sub-sections. It was not always easy to divide an item distinctly into either group since, although some issues were clearly non-academic, they could have a major impact on the academic success of a student. Nor was it easy to rank them as to their importance as this could change with the context and the individual. Some of the issues appeared to be isolated, affecting one or two students, whilst others were common, but when one realises that only 8% of students were interviewed, they may not be isolated at all. However, their influence on the outcome of students' performance could be an indicator of their importance.

4.4.3.1 Academic issues

Academic issues were further broken down into subject-related issues, student-related issues and lecturer-related issues.

4.4.3.1.1 Subject-related issues

The issues associated with the subject itself were by far in the majority compared with the other areas. Although, as mentioned earlier, the focus of this study centred on the theory presentation style and test 1, other associated issues were raised as to problems students have with the subject, and hence will be included here. The other components of the subject are mainly the examination at the end of the semester and the Thermodynamics laboratory practicals run during the course of the semester, which were generally run in parallel with the class theory and would have been performed by some students during the time that the spreadsheet and other study exercises were being undertaken.

There are probably many ways that one could sub-divide the issues raised by students under this broad heading. The Researcher has considered the terms and their context and divided them into major components associated with aspects of the subject, namely the computer spreadsheet intervention, the tests and Thermodynamics laboratory practicals. Hence, the tests and practicals, although not investigated as part of the intervention directly, were mentioned by students as having some problems associated with them, and are therefore included here. Other aspects such as books, notes and library use are also included.

Discussing first the computer related problems. The computer intervention, used as a self learning exercise, for students to teach themselves thermodynamics by interacting with the formulae whilst sitting in front of a computer, seemed to be a first for most, if not every student in the class. Some appeared to get on with the task fairly quickly, and progressed quite rapidly. However, from what was said in the interviews, many students appeared baffled initially as to what to do. Student A, who battled with the new presentation style, said:

> "...I'm just wondering if maybe the whole computer thing in the beginning of the the
> semester was such a good idea, because first of all you had to understand the formulas,
> ah then there if you understood the formulas then the computers worked, it's not a
> problem, but we very bad with the formulas. You did spend a couple of weeks with us
> going through all the different, um, what the different symbols and stuff and all that

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mean, um, but maybe a bit too fast with the new information...".

Student B, a repeat student, said of the computer spreadsheet exercises:
> "...taking a new sub a a new student into that course, to to to the computer exercises, I think eh it was the best eh introducti introduction part where we were being exposed to to computer exercises. I think eh it it did work because, ah, you can actually you can its practical you can actually do it and see that how how how a process operates and that's basically the idea to see.".

Student E said:
> "...initially uh wh uh most of the class was quite baffled about what to do, because there's no – there no ah, there were no ah question like given to us – we were just told to create a spreadsheet and no no um definite direction, you know, in which to take and um so initially it was just a little bit baffling, but afterward um working together in the groups, and then um we somehow put something together you know eventually a spreadsheet. Um, maybe maybe more direction could be given. It would have would have would have made it a lot easier...",

indicating that more thermodynamics theory would have been helpful. It should be noted that the same theory that is normally discussed in class, was presented in the lectures in the format as mentioned in Chapter 2.3.5, although only half the usual time was available, as mentioned in Chapter 3.3 and seen in Table 3.3. A short time later student E mentioned that their main source of information was supplied by friends, stating that:
> "...I had friends who had given me certain books from the university, so it was pretty much there already just had look through it and understand it, sift out what we needed and stuff...".

Later when questioned about library use student E said:
> "I'm not sure how to use the um the library",

a problem common to students as pointed out by several researchers and detailed in Chapter 2.2.3.

Student F, mentioned earlier in Chapter 4.4.2.5 as a surface learner, was a repeat student who registered late and only arrived after the spreadsheet assignments were completed and was handed the assignment sheets to do entirely on his own, but said about the spreadsheet assignment handout:

> "...As soon as rules and guidelines are set out, like you set that sheet out, those those exercise sheets, if for the first one and second one. As soon as you can go step-by-step through something, it's so much easier.",

and said of the layout of the assignment sheets:

> "...so much easier than than trying to go through notes and trying to see where I am and ah just, it was much easier following that.".

Interestingly, student F also mentioned an external source of notes, when he said:

> "I always work on my own but I use the other notes from the other people because...it's easier",

stating later that he did not use the library notes referred to in Chapter 2.2.2 and 4.3.2 as he found them "confusing" and not "particularly easy to get to grips with".

The next part to consider was the Thermodynamics laboratory where the practicals were run. Although this was not part of the study directly, the result obtained from it contributed 30% towards the class mark as seen in Table 3.4. It was mentioned when discussing difficulties students had with the course, and came up on several occasions, various concerns being raised by different students. The main issues seemed to be copying (plagiarism), cheating, teamwork, venue size (laboratory) and synchronisation of the practicals with class theory.

Generally the students seemed to manage to do the practicals without too much difficulty (i.e. taking the readings), student H stating:

> "Not really the experiment",

in connection with performing the practicals. However, the writing of the reports, the more difficult task since one has to try and analyse the results, seemed to be a stumbling block. When referring to the most difficult tasks in thermodynamics, student H said:

> " ...more of exams and practicals, you see, the reports, the writing of the reports."

and of the group allocations said:

> "...in practicals, and this is second time now and again I didn't. Because of the grouping, the people you get group with and its problematic…the communication between the students".

He also mentioned the rubric guidelines that students should get to assist in writing up the reports. This rubric appears to be known and available to some students and not others, student H being one who did not appear to have a copy. There is, however, a fairly comprehensive one that appears in the Thermodynamics III manual, and the Researcher had seen a similar one

being passed around by the other lecturer for this subject, who also ran the practicals for Thermodynamics II and who lectured the second half of the semester.

Also concerning the doing of the practicals, students B said:

"doing the prac, no, it's not difficult",

but of the writing up the practicals, he said:

"...writing the report about the prac that's the difficult part.",

because that is:

"where you we have to discuss and conclude about the prac itself. Then you have to…you must have an understanding of the prac itself".

Of cheating in practicals, student H was unhappy since:

"...it's unfair to me, if I'm not cheating. I mean they should [get caught]".

Cheating is becoming a major problem, not only in the Department, but in the Institution, as alluded to in Chapter 1.7.1, plagiarism being the main one with respect to practicals, even when the group members have signed a declaration that it is their own work.

Another problem related to practicals is the synchronisation between the class theory with the practicals, an almost impossible task given the numbers of students doing the subject, the available size of the laboratory and supervision of the sessions by staff and assistants. Student B said:

"the better way is to to actually, if you are on that eh section that corresponds with the prac, with that with that particular prac, I think you should do the prac during that section in class".

The last part of the subject related issues concerned the past papers. Having left out any reference to past papers in the study habits survey due to an oversight, the Researcher took the opportunity during the interviews to investigate the use that students made of the library services, especially in relation to past papers, as seen in interview questionnaire described in Chapter 3.11.2 and seen in Appendix I. Other areas of library concern are also covered later under non-academic issues, in Chapter 4.4.3.2, although it is not always easy to make a clear distinction between the two areas covered.

Students are continually encouraged and reminded to obtain past paper questions from the library which will give them extra problems when learning for tests and the end of semester examination. There was also a section on the Gantt Chart, handed out with the Learner Guide (Thurbon, 2006b, p.7) at the start of the semester, indicating additional problems they could find in Eastop and McConkey (1993), a recommended book for the subject, and a note suggesting that further problems could be obtained from the lecturer or from Joel (1987 and 1996), another recommended book. A reminder to use past papers was also mentioned on the Gantt Chart.

Seven students said that they had used past papers as study aids. Student A said he had not used them at all, and student F said that he had obtained past test papers and solutions from his friends, but had not had any time to read through them before the exam. One of the interviewees, student E, said that they had got hold of past papers from friends because, as mentioned previously in this section, they couldn't use the library.

Having obtained the papers, they were then asked what they did about finding out if they were doing things right. This proved interesting as several different approaches were taken, summed up in Table 4.15 below, the last three columns each representing a different style of approach. They either read the question and: considered the format of the question, or how they would approach the solution themselves, or did the problem by themselves or with a study group.

Table 4.15:   **How the Interviewees tackle past paper questions and solutions**

How they performed the task and who they did the problem with:	Considered the format of test and examination questions	Considered how they would approach the solution after reading the question	Worked out the solution				
By themselves	1	1	1		1	1	1
In a group				1			
Then compared answers with or consulted:							
Other students	1					1	
Working group members				1			
Friends						1	1
Lecturer		1	1	1			1
Tests and tutorial problems					1		1

When questioned as to how they check their answers, there were several totally different methods: they compared their answers with other students, or working group members, or friends, or the lecturer was approached, or they compared the past paper solutions with similar problems from tests and tutorials, generally in the order indicated going down Table 4.15.

Only three students took a multiple approach to check their answers, the others using only one comparison. However, as this was under interview questioning, one has to realise that this may not have been their only approach, they may have just forgotten about other methods they used. Another interesting point is that only four students mentioned approaching the Lecturer, student H saying during the interview that:

> "Now I see the need, but I haven't."

4.4.3.1.2 Student-related issues

Many issues relating to students' progress in Thermodynamics II could have been discussed in other places in this thesis. Whilst interviewing students the Researcher listened to the various comments students raised, trying to classify them into different areas. Concerning academic issues, students raised several points, some of which will be mentioned here. In doing this, the Researcher extracted keywords and phrases under a category termed "success or failure", in an effort to relate them to areas where students themselves talked about issues that may lead to either success or failure in the subject. Twelve were identified as positive, eleven as negative and seven as both positive and negative (i.e. they were used both in positive and negative statements). They are summed up in Table 4.16 below, the context of their use being highlighted in Appendix S, under the "Success or failure" section.

Considering Table 4.16, if one considers all the words in the "Success" column they are all associated with positive intentions. Similarly the "Failure" column terms are typically associated with negative issues. Finally the terms in the "Both" column can be taken both ways depending on their context as mentioned previously.

Success in the subject can result from taking an interest, being committed and dedicated, being consistent and disciplined, and so on. However, in the performance of all these actions the key area of importance is an understanding of the Language of Thermodynamics. This was highlighted in Chapter 2.3.2. Application of the theory and using past papers are two excellent

ways to achieve this. Several of these characteristics have been alluded to in various sections dealt with previously. Further, working in groups or teaching others can aid in the understanding and lead to a deeper approach to learning. The Council On Higher Education. (2010) report benchmarks "42 survey items that capture

Table 4.16: **Summary of terms students used to distinguish between success and failure**

Success (positive)	Failure (negative)	Both
application	blame the lecturer	attendance
assist students	cheating	commitment
consistency	demotivated	discipline
curious	lazy	Focus on strong/weak points
dedication	negative attitude	practical
hard work	not work hard enough	read
interesting	panic	tried
key importance	race [ethnicity]	
Language (of Thermodynamics)	stress	
method approaching problems	too late	
past papers	venue size	
understanding		

many of the more important aspects of the student experience" that "represent important student behaviours" (Kuh et al., 2005, as cited in CHE, 2010), amongst them being that students should be actively involved in tutoring or teaching other students, whether it be for reward or otherwise.

For student A, who was mentioned earlier in Chapter 4.4.2.4 as being de-motivated, the change of interest towards the subject came about during the more practical part of the subject, the second half, when normal lecturing took place, and when the theoretical parts of the subject

done during the computer exercises were applied in a more practical sense. He said:

> "I think when you came to combustion and steam plant, uh, then I kind of th thought –
> kinda figured out where all these bits and pieces come from...so it's now got a place,
> it's got a picture, I can...picture it, I could more or less understand it...so that's where
> the change came in".

If one had to surmise as to the type of learner this student may be, one would probably suggest
he was a visual/global learner. Felder and Brent (2005, p.60) suggest that visual learners prefer
"pictures, diagrams, flow charts, demonstrations" and describe that global learners generally
"may have trouble applying new material until they fully understand it and see how it relates to
material they already know about and understand". If one compares the result of the learning
styles from Table 4.8, it was noted that the class was generally biased towards being visual
learners.

As mentioned previously, when one considers the words in the "Failure" column of Table 4.16,
they all share a negative association. They could be broken down into several areas such as
failure to understand the theory and apply it, failure to work on weak personal areas, being lazy,
de-motivation, having a negative attitude, poor study techniques, panic under stress and so on.

Several students mentioned their own and the failure of others to understand the theory or being
able to apply it. Student B said:

> "most of the students, uh, are are actually having a hard time to actually apply their
> knowledge or theoretical knowledge on their own".

Student E, after intimating that graphs were a weak point at school, said of graphs:

> "...like for about graphs had never been my strong point, and somehow I I don't seem
> to get graphs or understand them...",

pointing out further that:

> "...after all these years I've chosen to like ignore it, and you know cause I had you
> know um bad taste left a bad taste in my mouth but um ja, that well that's presented a
> bit of a difficulty with me...".

Both said later that they would fail because they had not put enough work and effort into the
subject as a whole. Some students seem to get de-motivated quite easily and quickly, as pointed
out previously for student A.

Students often come into the subject with a negative attitude, partly from rumours that they have heard from previous students. Student H said:

> "people they come with that idea that its difficult, so once they fail, um, its given that they were going to fail anyway".

Concerning study techniques, student E, when asked to describe what others attributed to their success, said that:

> "They work with the tuts and they work consistently. They try to understand, they they probably pay more attention in than I do, or they work at home and they go home and they they do a little bit of work every day",

and then student E commented that their own study was:

> "not a set routine".

When student C, who had a deep approach to learning, was asked what they thought contributed to others not doing well said that:

> "I would say they panic and they don't study and last minute they start asking questions on how to do that and not understand the fundamentals of that section itself, and they want to know how to calculate a certain problem, without understanding the dynamics of the problem itself."

4.4.3.1.3 Lecturer-related issues

There were several issues raised by students about the lecturer. These included the style the lecturer adopted for class theory, the lecturer's approach to students and the subject, and the colour or race of the lecturer.

In Chapter 1.5 the Researcher introduced his current classroom lecturing style as very similar to "the inquiry method" (Postman & Weingartner, 1971, pp.38 - 47). The approach of answering a question with another question is not always popular with students as they like to get a straight answer to their question. However, the Researcher has found that they do not then tend to try and reflect on what they asked and why, and that an immediate answer given often does not solve the problem, as another student will ask the same question again, sometimes only several minutes later. The Researcher's method evolved over the years, by accident and frustration with

the lack of questions asked during lectures. The fact that it was already recognised and documented as a particular style was a surprise and revelation to the Researcher. Student D confirmed this style when he said:

> "...you do it a lot sir, because you they tend to tend to ask you a question and then you say you won't answer that question you want students to answer that question Sir, that question that you gave you gave the lecturer..."

Student B commented on the lecturing:

> "...but eh thermodynamics alone it's, it's eh it's a bit eh complicated when it comes to to to understanding, and eh I don't think eh the introduction of it has been eh the st or the style of lecturing has been changed it's it's the same style of lecturing and eh it's a bit too difficult for more of for students."

When it comes to the Researcher's approach to students and the subject, he is always mindful of keeping up academic standards, as well as being fair and impartial to all students. Attempting to treat them all equally is a difficult path to tread, and one often has to be tough to keep students in check. The students frequently take this as an indication that the Lecturer is harsh in his treatment of them, student H commenting, generally about what other students say when he said:

> "people they they study hard, they know that eh thermos probably its difficult and then Mr. Thurbon is is a tough lecturer to please, you know".

Only one student, B, brought up the delicate subject of race, albeit in the context of language, meaning in this case English rather than the subject's language, and its associated problems, when he commented:

> "...considering the the language and eh it is an advantage for us when we have a a lecturer who is the same colour as us, where we can actually consult the lecturer to to have a a a a eh the sa ah what did I as a.. to to actually consult the lec the the lecturer. It's it's eh a bit easy when it is a lecturer same as your colour, but I I think eh the language is actually affecting us".

4.4.3.2 Non-academic issues

These were issues that were raised by various students during the interviews, mainly as

regarding **sub-questions 2** about problems experienced. Although many are not concerned with the subject Thermodynamics, their impact can have a significant part to play in the final academic success of a student. If one were to rank these according to their influence on student success, some of these issues could outrank the academic issues mentioned in Chapter 4.4.3.1 and elsewhere. Six areas have been highlighted here and each will be discussed in turn. They are: finance, book, library, venues, attendance, and transport. However, as will become evident, a lot of them relate back to finances as this is a key issue and a major stumbling block for many students, not just in this institution, but right across South Africa.

Finance related issues have become a major concern to all involved in academia in recent years, as highlighted in Chapter 1.3. In the report mentioned in Chapter 1.3 by Pillay and Wallis (2009), highlighting the DIT's problems, some of the 54% of first time registration students who dropped out from the Faculty of Engineering and the Built Environment between 2004 and 2005 may well have included some students in this Thesis research group. Although placed in the non-academic section, it plays a significant role right across student life and can be directly or indirectly the main cause of other problems, such as those discussed in several of the following sections. In a report by Letseka, & Maile (2008, p.8) they state that "many of the students coming from these [poor] families depended on their parents or guardians for financial support to pay their fees and/or supplement what they get from NSFAS to provide for essential living expenses. Many of those who dropped out indicated that they worked to augment their meagre financial resources, no doubt adding to their stress levels and distracting them from their studies."

A NSFAS [National Student Financial Aid Scheme, set up and run by Government to assist students studying at Tertiary Institutions] scheme covers tuition fees, accommodation, food and books to students essentially on an "as needs" basis. However, even this is problematic as students sometimes do not get these fees distributed till late in the semester causing problems with access to certain areas, especially things like test marks and class marks to see how they have done as these are withheld until outstanding fees are paid. Although some materials are paid for in the subject fee, text books generally aren't and as seen in Chart 4.2 less than half the students own their own text book for this subject, with the majority obtaining notes from the library as seen in Chart 4.1, again probably due to finances.

Concerning books and the library, several students mentioned that they consulted the

recommended books in the library. Considering the library and its use, student C said:

> "...if I'm not mistaken I think there are two copies of Rayner Joel in the library that are allowed to be taken out overnight – that's the fifth edition and the problem is, I think, we using the same textbook as the guys who are doing Thermos III."

The limitations on the number of books that students have access to, together with the problem of students not being able to afford their own text books (mentioned above), creates a great strain on available resources, especially the library text books which, as student C pointed out above, have to be shared by all the students registered at all levels doing Thermodynamics. Theft of library books has also been an ongoing problem as has the defacing of the books themselves.

Another resource available in the library is the collection of the entire past exam papers. Most interviewees, as discussed in Chapter 4.4.3.1.1, said that they consulted either past papers or past tests (not available in the library). However, there are neither worked out solutions nor answers to the past papers available in the library, as this is library policy. Thus students are not able to check if they have achieved the correct solution, other than the methods mentioned in Chapter 4.4.3.1.1.

A new problem that has surfaced in recent years is that, although the past papers are compiled and placed in the library, many of the pages have been torn out, presumably by students wanting to obtain copies of the papers but who cannot afford the costs of duplicating them. This has become a fairly common practice across many disciplines and is a major concern for all. Again this is probably due to financial constraints.

Concerning venues, the four main uses of venues would be for lectures, tutorials, laboratory practicals and computer facilities. During the course of this study there did not appear to be any problems associated with the lecture venues, since the normal lecture venues were used, and they were generally trouble free, other than the unavailability of overhead projectors, an ongoing problem within the DIT.

The computer laboratory, as mentioned in Chapter 3.4, also served as the tutorial venue, as it was a triple period as seen in Table 3.3. Although the Researcher managed to answer some of the tutorial problems during this time, much time was invariably lost due to other problems,

mostly computer related, as mentioned earlier in Chapter 4.1.4. Although the computer problems were not commented on by the interviewees, the availability of the computer facilities outside of the formal lecture time was. Student E, whilst commenting about completing practical reports, and having to pay for outside services, stated:

> "internet access is not ah we don't have like that much. It comes on in the afternoon, to the ones that we have access to. And the LAN's, theres not many LAN's. It's kind of difficult because you have to either deal with the Internet Café and pay for it instead of being able to use it here."

Whilst the computer laboratories may have afterhours access, another problem has been and still is, the safety of students during that period. The Campus grounds are not a safe place for students or staff, particularly after hours.

Another issue that was raised relating to venues was that of the practicals. There is a dedicated thermodynamics laboratory in which all the practicals are conducted. This is obviously too small to accommodate all the class at once, hence a timetable is set up whereby students come on a rotation basis to do various experiments. This means that not all students will have dealt with all the class theory before they get to do a particular practical, as mentioned in 4.4.3.1.1. Only one student, student B, commented on the size of the laboratory when he said:

> "well maybe the the venue for the pracs may be too small for for for for students".

Considering student attendance of lectures, this continues to be a problem since some students do not attend all their lectures. They may miss lectures for various reasons, some avoidable, others not, as highlighted in the next paragraph. One of the commonest times is around test times when they frequently miss lectures to study for the upcoming test, especially if it is on that day. Arriving at a lecture where there are only a few students is annoying for lecturers who have a syllabus to finish. Some lecturers will then cancel that lecture due to low attendance. However, one student, D, had this to say about lecturers doing that:

> "...when we attend the lecture because of the time and then they see, ag, most of the students are not there, when they come and then the lecturer will ask 'Where are the students' and they say 'they are studying for the test', and then he will say 'ag, this a disappointment, we've got to cancel the lecture', because most of the students are not there and then most of when they do that, they tend to not finish the syllabus, because of that.".

He then went on to say:

"...it's not the lecturer's fault or the students who are there..."

and that lecturers should carry on with the lecture to be fair to those who did arrive.

Finally, although transport did not appear to be a major issue for the students interviewed, student I had a particularly worrying comment to make about transport problems when he mentioned that he missed every Thursday's lecture due to not being able to afford public transport costs for every day of the week. This was particularly disturbing as Thursday was a double period for Thermodynamics II at the time. Hence this student missed 50% of weekly lectures for the subject. Again this relates back to finances as discussed at the beginning of this section.

4.5 The semester test marks

The analysis of the semester marks was done in two parts. The first part was to compare the intervention semester's test one and test two scores, and the second part was to look at the intervention semester's test one and two scores and to compare them with previous semester test one and two scores. This related to **sub-question 3**, mentioned above Chapter 2.5 and seen in Table 3.1.

4.5.1 Reliability of intervention and previous semester test 1 and test 2 scores

As mentioned in Chapter 3.6, the statistical analysis package SPSS was used to analyse the data gathered from all the class test scores, both the current semester and the previous five semester test marks, which were used as a control group. The previous semester marks were then compared with the current semester marks, the assumptions as to the reliability being discussed below.

Several assumptions that must be considered here include:
- all students in any semester have equal capability
- all tests written were of equal difficulty and covered the same work content
- students were given the same opportunities in each semester
- the same lecturer covered the same sections in the same manner over the same time period each semester

▪ the test scores carried an equal weighting in each semester

Considering each assumption separately:

▪ all students entering the DUT are required to meet the same minimum standard as detailed in Chapter 3.9.1. Potentially, they should thus all have very similar capabilities. Although this is a fairly broad statement, all local institutions operate essentially from the same premise.

▪ each semester's tests, although they cover typically the same portion of the syllabus (Thurbon, 2006a) will have different questions, of differing length, designed to test students' knowledge of that portion of the syllabus. Thus, although they should be of equal difficulty, there will be some variance from one semester test to the next. The other factor is the timing of the test. This has to fit in with the calendar and holidays, mentioned in the paragraph below. The tests would normally be held in different weeks during a semester, allowing different points of departure for different tests. This difference was not considered to be a significant factor, as the bulk of the questions posed in the papers covered very similar work each semester, and were run at about the same week in each semester.

▪ each semester from year to year will vary in duration by a week or more. Also, in the first semester there are more public holidays than in the second, reducing the available contact time with students. However, the same amount of work needs to be covered. There would, therefore, have been some slight variation in contact time with students, but this is not considered to be a factor that would greatly influence their success or otherwise, since they would be tested on the same content each semester. Another factor is the unrest which has occurred on campus at various times over the last few years. This has often been in the first term of a semester, affecting when a test was to be written, and influencing the content of the test to a certain extent, as mentioned in the previous paragraph. This was not considered to be a significant factor, as work missed would have been made up before a test was written.

▪ since the merger of Technikon Natal and M. L. Sultan in 2002, this subject has been shared by two lecturers (one from each institution) from semester 2, 2002 onwards. In 2003 the two classes merged into one combined group, and both lecturers have continued sharing the syllabus. This has typically involved the Researcher taking the first half of the subject in the first term, and his colleague taking the second half in the second term. Thus each has taught the same portion and set the same tests accordingly, over that time period. The only exception was semester one 2006, when the roles were swapped and the Researcher took the second half of the semester.

- although the actual weighting of test one in the intervention semester was different compared with previous semesters, as seen in Table 3.4, this difference in weighting did not affect the comparison of marks as all test marks used in the analysis were expressed as percentages.

A summary overview of the mean and standard deviations for the intervention semester and the combined control semesters marks appears in Table 4.17 below. It can be seen that the combined and intervention semester means and standard deviations for test 1 and test 2 are similar, but that the test 1 and test 2 means and standard deviations are quite different.

Table 4.17: Comparison of combined previous and intervention semester test mark means and standard deviations

	Test 1		Test 2	
Semester	Combined	Intervention	Combined	Intervention
Sample size	460	53	617	53
Mean	40,85	38,67	49,87	55,06
Standard deviation	17,786	15,427	24,544	27,389

4.5.2 Comparison of intervention semester test 1 and test 2 scores

A separate comparison using a Paired Sample T-Test was made using only the study semester test one and two scores, Being a dependent test, this was limited to students who had completed all the required assessments. Hence those who had not completed either assignment, or had missed any other assessment were removed first, leaving only 53, still a reasonable size to use in a statistical analysis. The SPSS output for this test is shown in Table 4.18 below.

Table 4.18: Output Tables of Paired Sample T-Test for Tests 1 and 2

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	test 1 score	38.67	53	15.427	2.119
	test 2 score	55.06	53	27.389	3.762

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	test 1 score & test 2 score	53	.448	.001

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	test 1 score - test 2 score	-16.385	24.682	3.390	-23.189	-9.582	-4.833	52	.000

Considering the Paired Samples Test output (the third table of Table 4.18), since the two-tailed significance value is less than 0,05 it can be concluded that there is a significant difference between the two scores (Pallant, 2001, p.183; Field, 2000, pp.231-232). Also, since the confidence interval does not contain a zero, it can be concluded that there is a difference between the two test scores, test 2 scores being higher than test 1 scores in this case (Field, 2000, p.411). Calculating the effect size, as indicated in Pallant, J. (2001, p.184), gives a value of 0,31, suggesting a large effect size since it is greater than 0,14 (Cohen, 1988, as cited in Pallant, J.,2001, p.184). This effect size indicates a large difference in the two test scores between the intervention test one score and the conventional lectures test two score. The null hypothesis of no difference in the scores is therefore rejected here. Analysing the output of Table 4.18 further, the correlation of 0,448, as seen in the second table of Table 4.18 indicates a moderate correlation between the two sets of marks (Mulder, 1987, p.73), i.e. the difference between the test 1 and test 2 scores is moderately significant. A further test, the Wilcoxon Signed-Rank Test, which is a non-parametric test used to compare two sets of scores from the same group (Pallant, 2001, pp.261-263; Field, 2000, pp.55-57), in this case the two class tests from the same students, was carried out using SPSS. It was assumed that the data were distributed symmetrically around the median. The output of this test is seen in Table 4.19 below.

Table 4.19:   **Output Tables of Wilcoxon Signed Ranks Test of Test 1 and Test 2 Results**

NPar Tests

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
test 2 score - test 1 score	Negative Ranks	13[a]	19.46	253.00
	Positive Ranks	40[b]	29.45	1178.00
	Ties	0[c]		
	Total	53		

a. test 2 score < test 1 score

b. test 2 score > test 1 score

c. test 2 score = test 1 score

Test Statistics[b]

	test 2 score - test 1 score
Z	-4.094[a]
Asymp. Sig. (2-tailed)	.000

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

In the Ranks Table of Table 4.19 the positive ranks outnumber the negative ranks, indicating that the test two scores were generally higher than the test one scores. Looking at the Test

Statistics Table of Table 4.19, the z-score based on the negative ranks, is -4,094. This is at a two-tailed significance of 0,000, which is less than 0,05. This confirms the previous result deduced from the T-test, that the null hypothesis is rejected, and that the two test scores are significantly different (Pallant, 2001, p.263).

Graphs 4.10 and 4.11 below show the distribution of Test 1 and Test 2 scores for the intervention semester.
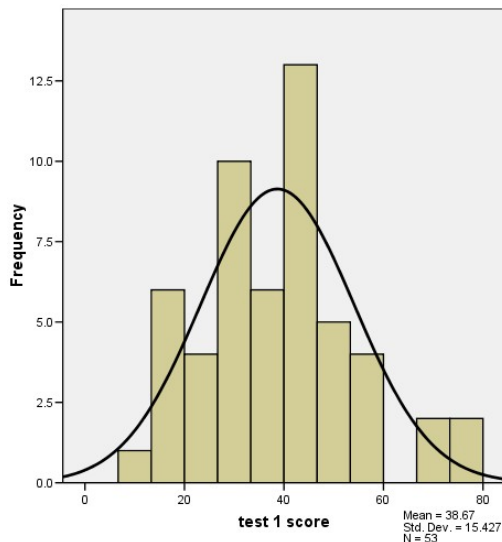
GRAPH 4.10: Distribution of Test 1 scores   GRAPH 4.11: Distribution of Test 2 scores
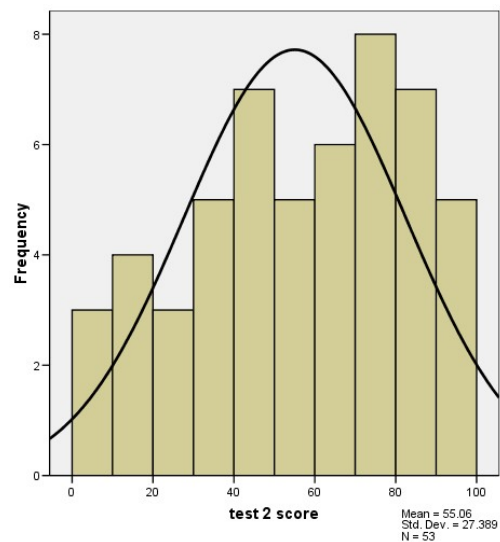
Although neither test marks showed a significant deviation from a normal distribution, the second test did show a slight left skewness (Walpole & Myers, 1978, p.43) as seen in Graph 4.11 (skewness = -0,308, giving a $z_{skewness}$ = -0,942 indicating a left skewness (Field, 2000, pp.40-41)).

4.5.3 Analysis of differences between tests 1 and 2 in the intervention semester

From the differences between the two test scores, the first test being on the work covered by the computer intervention and the second test being work covered during typical classroom lectures, one can draw several different conclusions. These are highlighted below, not necessarily in order of significance.

- Conclusion 1: the differences in test 1 and test 2 scores is moderately significant
- Conclusion 2: test 1 was conceptually more difficult than test 2

- Conclusion 3: test 2 was easier than test 1, or was better performed
- Conclusion 4: the impact of an alternative approach to lectures using spreadsheets could have had an impact on student test results. It could have increased their understanding of concepts and hence helped them to get higher marks in test 2.
- Conclusion 5: the concepts of thermodynamics, which were tested in test 1, were not well understood by students, whereas the application of thermodynamics, which was tested in test 2 was more interesting, motivating students to do better.

4.5.4 Comparison of previous and intervention semester test 1 and test 2 scores

All the test 1 and 2 marks for the previous five semesters were combined into one table, and a histogram generated in SPSS for each test, Graphs 4.12 and 4.13 below. Both show a fairly normal distribution although the kurtosis for the curves is different, a trend similar to that of the intervention semester. Comparing these histograms with those for the research semester, Graphs 4.10 and 4.11, one observes a similar trend with regard to the spread, test 2 being broader than that for test 1.
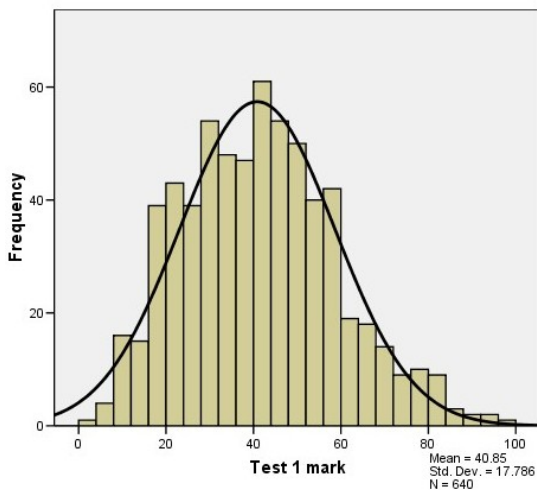
GRAPH 4.12: Histogram of all combined previous semester test 1 marks
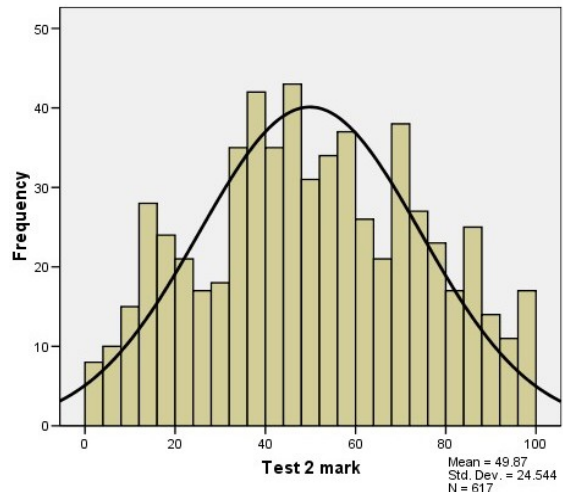
GRAPH 4.13: Histogram of all combined previous semester test 2 marks

A Oneway ANOVA test was carried out for all six semesters simultaneously to compare them with each other. The results for each test are summarised in the table in Appendix T (set 6 being the intervention semester results in each instance). If one compares the means and standard

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deviations for the two tests separately, one can see a similar trend, the exception being semester 1, 2006 marks (set 5 in Appendix T), where the means are almost reversed. In this semester, the same two lecturers swopped roles, taking each other's usual sections. The F distribution score is high for both tests (12,055 for the test 1's and 9,018 for the test 2's). This tells us is that "there probably is not a significant difference between groups" (Miller et al., 2002, p.145). It also tells us that "the means are not all equal but it does not tell us which particular means are unequal" (Christensen, 1996, p.127).

A further test, a Post Hoc Tukeys Test, was carried out on the data, to see how closely each semester's marks correlate, the one of interest being the 6th set of readings in each case, these being the intervention semester values. The results of this test, for both test 1 and test 2 appear in Appendix U. It can be seen that there is a close correlation between sets 1, 2, and 3 for the test 1's, and sets 1 and 4 for the test 2's, with significance values in excess of 0,9 in nearly all cases. "Any figure less than 0,05 is deemed significant" (Miller et al., 2002, p.149), hence values in excess of 0,9 indicate that the difference between the test 1 means is not significant. Set 5 was the exception, where the lecturers swopped roles as mentioned previously. This was verified further by doing a Oneway ANOVA test for test 1marks using only the three sets specified above. The ANOVA test yielded an F score of 0,659 and a significance value of 0,577 which is still in excess of 0.05 (Miller et al., 2002, p.149). A similar ANOVA test was run for test 2 marks using only the sets mentioned above, giving an F score of 1,163 with a significance of 0,314. The fact that both these F scores are much closer to one than the F score of the analysis using all six sets of data, verifies that they are a closer match. This indicates that there is little difference in the variances, and the means are equal once the fifth set of data is removed, this being the semester where the same lecturers swopped roles. Thus the null hypothesis, that there is no significant difference between the intervention semester test 1 and test 2 scores and previous semester test 1 and 2 scores, is accepted.

4.5.5 Analysis of differences between tests 1 and 2 in the previous semesters compared to the intervention semester

If one compares the previous five semester marks with the intervention semester marks one could come to similar conclusions as in Chapter 4.5.3. These are highlighted below, again not necessarily in order of significance.

- Conclusion 1: there was no significant difference between the test 1 or test 2 marks as compared with other semesters.
- Conclusion 2: test 1 marks were consistently lower than in test 2 in all semesters, including the intervention semester.
- Conclusion 3: test 2 was perhaps easier than test 1, or better performed.
- Conclusion 4: the impact of an alternative approach to lectures using spreadsheets had little significant impact on the pattern of student test results.
- Conclusion 5: the concepts of thermodynamics, which were tested in test 1, were not understood well by students, whereas the application of thermodynamics which was tested in test 2 was more interesting, motivating students to do better as it was more practical.

In Chapter 5 the study questions introduced in Chapter 2 and highlighted in Table 3.1 will be discussed. Also questions raised for further investigation will be detailed as well as other areas of interest for inclusion and follow-up.

Chapter 5

CONCLUSIONS

5 Overview

One of the main aims of this thesis, as described by the **Primary Question**, was to investigate how delivery affects student understanding. To investigate this, an alternative approach to teaching Thermodynamics II, using spreadsheets developed by the students as an interactive learning tool was investigated. This was achieved by following two different styles of teaching and learning for the same class over a one semester period, as described in Chapter 3.3. Each half semester was also taught by the same lecturer who normally took those sections, in the same manner and over the same duration as previous semesters. For the first half of the semester, the subject was delivered using a combination of typical lectures, combined with interactive computer laboratory sessions using a constructivist approach. During that time two spreadsheets were developed by students, in groups of three, to interact with the main formulas encountered in the subject. These formulas were introduced during lectures over that period. As a form of reflection the student groups had to peer assess another group's spreadsheets, guided by a rubric. Each computer assignment counted 5% towards the student's class mark, seen in Table 3.4. The second half of the semester was delivered in the usual manner of conventional "chalk and talk" lectures.

To investigate how students learn Thermodynamics and what problems they have studying Thermodynamics and why, two sub-questions were formulated, one to investigate learning, **Sub-Question 1,** and the other, **Sub-Question 2**, to determine problems. To assist with these two sub-questions a student study survey was devised, as described in Chapter 3.9. It was given to each member of the class during one of the computer sessions, and is analysed in Chapter 4.2. To further interrogate these two sub-questions, at the end of the semester interviews were held with nine students from the class, chosen initially by purposeful sampling but later by accidental sampling, as many students declined the interviews after initially indicating that they would participate. The background and setup of the interviews is detailed in Chapter 3.11 and relevant aspects of them are discussed in Chapter 4.4.

As a means of determining what impact the intervention had and if it improved pass rates, **Sub-Question 3**, two comparisons of marks were made. The first was a comparison between the two summative tests held during the semester, one after the computer intervention and the other after the normal lectures period. The tests were run in the usual manner and form and carried the weightings seen in Table 3.4. The two intervention semester test results were analysed using a paired-sample T-test together with a Wilcoxon Signed-Rank Test using SPSS to see if there was any difference between them, detailed in Chapters 4.5.2 to 4.5.3. The second comparison was between the marks of the previous five semester's tests one and two using a Oneway ANOVA test in SPSS to determine if there were any significant differences between the intervention semester test marks and previous semester's test marks, detailed in Chapter 4.5.4 to 4.5.5. As mentioned previously, the same lecturers had covered the same material over the same time period in the previous semesters using only a typical lecturing approach.

Further, as a test to determine the students' knowledge of Thermodynamics gained during the computer sessions and before the first test, a concept test, described in Chapter 3.10 and analysed in Chapter 4.3, was devised. This test was in the form of a spreadsheet into which students had to put a "1" next to the answer they thought was correct, essentially a multi choice type test. It marked their answers automatically and immediately displayed how well they had performed as a percentage for each of four separate sections, as well as a combined total for the test as a percentage. However, this test carried no mark towards the semester class mark but was a test providing immediate formative feedback.

5.1 Summary of Primary Question

The Primary Question was to investigate how delivery affects student understanding. Different forms of delivery were discussed in Chapter 2.2. The primary method of delivery at the DIT is lectures, typically interspersed with tutorials. Most subjects have a prescribed text book, augmented by class handouts. A set of notes students could photocopy were put in the library to supplement the various sections of this subject, with the recommended reference book being Eastop and McConkey (1993) which is the prescribed book for the follow on subjects in this field. Computers are another option which can be used as an addition or alternative to lectures and tutorials in the form of online or offline teaching and learning, as defined and discussed in Chapter 2.4.3.

Each of these modes of information delivery was investigated during the course of this study,

the main one being the computer intervention. Lectures, tutorials and the computer intervention followed by text books and library use will be discussed below.

5.1.1 Lectures, Tutorials and the Computer Intervention

Since the lectures and the computer intervention, which incorporated the tutorials, ran in parallel and were integral to the study they were compared to each other as two different styles of teaching and learning. In performing the main component of the Thesis the number of lectures was roughly halved as seen in Table 3.3, the rest of the time being spent in the computer laboratories where students, operating within a constructivist approach as detailed in Chapter 2.1.7, were free to both do their tutorials and generate their spreadsheets. However, to do the latter required an understanding of the former such that the method of solving the tutorial problems could be analysed and then integrated into the spreadsheet. To align the spreadsheet with the assessment criteria of the marking rubrics required the students to become familiar with the terminology and nomenclature associated with Thermodynamics.

Student C, a deep learner, said:

> "for the computer presentation method you really have had to have acquired the knowledge before you went into the session itself, because you could not do anything on the PC if you did not know the basics of what you are doing, so ultimately you actually had to sit down with the text book and you had to listen in class to learn the material".

The lectures that were done during this time period covered essentially the same amount of work that is normally done in twice the time. The quantity of work covered did not appear to affect the student's ability to utilise it. However, interview student A, who also indicated that one needed an understanding of the formulas before the computers worked appropriately, seen in Chapter 4.4.3.1.1, also indicated that the lectures were possibly too fast. Conversely, concerning the pace of the lectures during the computer intervention Student E said:

> "for the beginning it it went at a fairly okay pace".

Although the Researcher was aware of the limited lecture time and tried to minimise the impact, a lot of lecture time was also taken up trying to explain the various aspects and requirements of the interventions. Aulls (2002, as cited in Kirschner, Sweller and Clark, 2006, p.79) reported that to achieve all the learning outcomes, teachers had to spend a great deal of time on both

"teaching content and scaffolding-relevant procedures". In this study, students became visibly frustrated at times when the Researcher started to explain things required for following computer sessions. Interview Student G said:

> "we spent most of the time doing spreadsheet and then – during lec lecture time probably the lecture takes up about an average of 45 minutes, so on that 45 minutes, we took around about 30 minutes briefing us with spreadsheets so – and then the rest of the time you just brushing up on on the sub on the ah on that particular section".

However, he went on to say later that the spreadsheets weren't a problem for him but rather the subject's theory and, when comparing lectures with the computer exercises:

> "Ja Sir, I think this the spreadsheet has, it has some bit of an advantage in terms of, uh, doing the work on your own so it makes you understand more than just sitting back, somebody's explaining something to you, but if you just give me the work and then I sit and then I know what to do so I think – ja, I think the spreadsheet. Ja, I think it has some bit of an advantage in terms of understanding some of the stuff Sir".

Hmelo-Silver, Duncan and Chinn (2007, p.102) state that "A great deal of structure is provided through scaffolds in the IL and PBL environments" and that one of the important questions to ask is "what kinds of support and scaffolding are needed for different populations and learning goals" (ibid, p.105). The Researcher has to wonder if the traditional lectures approach was the best approach to follow during the intervention.

The second half of the semester was completed in the normal fashion of lectures as mentioned previously. Student A, described previously as a visual learner in Chapter 4.4.3.1.2 and who also professed, during the interview, to being a global learner who liked to see the whole picture first, when comparing the two methods of presentation performed during the semester said:

> "I don't know if it's because I'm just understanding the work now, but I much preferred the lecture method, the second method that we tried. The first one I found very confusing too because I didn't understand the computer program so well",

indicating that he also battled with the formulas of Thermodynamics and trying to get them to work in Excel, saying later:

> "when we moved over to lecturing where there are the notes, there are all the pictures, this is what's up, ok, now its dawning on me, oh this is what's happening so yes it has been a big difference".

He indicated later, once he understood the equations and how they worked, that he would likely

have not had such a problem using them in Excel. He also said that he had taken on an extra subject that semester and had battled with the workload, although he spent four to five hours an evening studying. Of lectures in the first few weeks, during the computer intervention Student A said:

> "…we very bad with the formulas. You did spend a couple of weeks with us going through all the different, um, what the different symbols and stuff and all that mean, um, but maybe a bit too fast with the new information. We still trying to get into the learning mode and all of a sudden we're expected to learn all these huge formulas, so yes, you hear it in class, I'll glance over that later and then when you get down to taking pen in your hand and writing then you really start concentrating but just sitting back in class and just hearing all these, like words being thrown at you, it's like it goes in the one ear and goes out the other".

As a suggestion to change the approach in the beginning student A said:

> "…kind of half the class or more than half the class battled with that whole concept. Um if I could have request if I could have done this from scratch again, I think, I think what would have made a big change is, um, first get us to understand the formulas properly, a first off overview then formulas and then give us a spreadsheet, then we'll do well not do a hundred percent because I mean it's not that difficult".

Student H indicated that he had not got much out of the computer intervention and said of the two teaching and learning approaches:

> "If I were to choose, I I would go for that that chalk one, because the the computers, I i its there's a lot, it's demanding I would say. Because you got to know your computers first... program, and then you have to know the concepts and get them right and then combining the three it becomes very difficult".

Student D, when comparing the second computer assignment with the first, said:

> "after assignment one, maybe we fin, we find it easier to do assignment two, because we knew what eww we did in ah for the first assignment, and we know we knew our problems were were about, but then for assignment two time was short",

indicating that they were running out of time to complete assignment 2 in the time available. The number of interventions was probably too high for the time available and the Researcher has to admit being at fault here in possibly being over-enthusiastic and trying to do too much in the time available. The students interviewed generally seemed to initially have more difficulty

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programming Excel than with the Thermodynamic theory, but found things easier to do after assessing assignment 1, student D saying for the second assignment:

"…for doing it for the second time, I find it much easier to understand".

Comparing the two styles of presentation for the two halves of the semester, student D said:

"the time we had for Mr xxxxxx for the assignment we had more time to study then to get knowledge from out of him…listening, doing the tuts, but exactly cause the for assignment, we did have the time to go for a lectures, we did have the time too for a tut [but]…we had to include in the while we do the computer assignments",

indicating that generating the spreadsheets whilst at the same time trying to do tutorials was problematic. These problems were exacerbated by the computer problems experienced whilst in the laboratory, as described in Chapter 4.1.4, although the Researcher did assist students with tutorial problems whilst in the computer laboratory. Although student D indicated that he, and other students, were not sure what to do with the computer assignments, he went on to say:

"…but at the end of the day, we learnt something from it".

5.1.2 Text books and Library use

The area where text books and library use were investigated included the study habits survey, analysed in Chapter 4.2 and the interviews, discussed in Chapter 4.4. The study habit survey looked at what interaction students had with the library and the interviews considered what use the interviewees made of the library and what text books, notes, etc. they consulted in learning Thermodynamics.

Student A said of the recommended books:

"the recommended book yeh, but I hear that the other one is a lot better the Roel Rayner Joel is a lot better so I'll I'll look into that"

and of the Library notes, which he didn't use much in the early sections, during the computer exercises, but later, for the lectured half of the subject:

"I've used thoroughly, especially for combustion and steam plant. I can understand the notes, um, the only thing that that it lags a bit is maybe the calculations side".

Student D indicated that he had a full set of library notes which he found easy to use, again especially combustion and steam plant, but that if Joel (1987, 1996) had better information he

would use that instead as it was much simpler than the other recommended text book. Of the other recommended book, Eastop and McConkey (1993), prescribed for the follow on subjects, he indicated that it had more than was required for Thermodynamics II and not enough related to Thermodynamics II, so he hadn't used it. He also indicated that his friend had Eastop and McConkey (1993), but hadn't used it either.

Several interviewees said that they had obtained copies of the library notes and had used them extensively. There are also copies of the recommended books in the library, but student C indicated that the problem with the library was the availability of the recommended books, especially as their use is spread amongst other classes of students studying thermodynamics as well.

As highlighted in Chapter 3.9.3, O'Brien & Symons (2007, p.414) found that science students were the least likely to consult a librarian and that 23% never used the library, and in Chapter 4.2.3 that students were less likely to consult a librarian than their professors. In this study frequency of library use was not found to significantly influence pass rates although it was found that students who used the library more frequently had a higher pass rate, as discussed in Chapter 4.2.3. It was also found that although 60% indicated that they had done a library orientation course, 4% never used the library and 16% used it only monthly or less, and for those who did use it regularly books were the most common use. Also 72% indicated that they had consulted a librarian for assistance. It is felt that students should be encouraged to do the Library orientation course to get to know how to use it effectively as this resource is often underutilised.

5.2 Sub-Question 1 – How do students learn thermodynamics?

Information relating to how students study Thermodynamics gathered from both the interviews, discussed in Chapter 4.4, and the study habit survey, analysed in Chapter 4.2, are discussed below.

As was discussed in Chapter 2.1, students approach their learning in different ways or styles. To create a deep approach to learning, described in Chapter 2.1.2, requires dedication and perseverance. It is also a two way process, as it takes the right approach to teaching to encourage students to adopt a deep approach to learning. In Chapter 4.4.2.5 different students

interviewed took very different approaches to learning. Student C, described in Chapter 4.4.2.5 as a student who took a deep approach to learning, got to understand the basics first, which enabled him to understand the later sections. In describing how he approached his learning he said:

> "…still you do not have an understanding of this one chapter. You have referred to various sets of notes but still you do not understand it, and that is where you would need a lecturer to maybe shed some light on on on the difficulties that you are having".

and later said:

> "I have been putting a fair amount of work into understanding material and whenever I I encountered a problem I would consult a lecturer immediately, such that I would get clarification upon that section before we got to the test environment…and the availability of lecturers when I had problems"

and of studying technique:

> "I wouldn't say there is a specific technique I use Sir. It's just old school sitting down with a text book and reading".

Student F, described in Chapter 4.4.2.5 as adopting a surface approach, said he preferred to learn things "parrot fashion", a sure road to disaster.

Concerning the consulting of a lecturer or otherwise to assist with problem solving realised some interesting results, mainly in connection with the tackling of past papers. In relation to the use of past papers, mentioned in Chapter 4.4.2.5 and discussed in detail in Chapter 4.4.3.1.1 and 4.4.3.1.2, student A said:

> "The problem is the availability of the solutions thereof, because if we do a past paper there is no way of knowing whether you're right or wrong".

This problem was discussed by several interviewees, some indicating that if they did a problem they would compare their answers with other students and if they all had the same answer they would assume that they were correct. Only about half indicated that they would consult the lecturer to find out if they were correct. O'Brien & Symons (2007, p.414), as described in Chapter 4.2.3, found that students most often consulted their fellow students. However, student C, concerning getting assistance from other students, said:

> "…the only time I would either interact with another student is if I had a problem and you find that the hours during which I'm working on this material does not allow me access to a lecturer, because most of the time I do my studying in the evenings. So what

I would do is, I would consult other students that I know may have an understanding of the sa of the section I'm working on…".

Asked what extra support may be helpful, student D said:
"I would like to get to to go to the the students who are, who are…doing Thermos III, to give us their knowledge what they did in S2. I think that's extra support we'd get from them, if they are willing to give that, give us the knowledge they have",
but of tutors:
"but then for tutors, maybe you won't understand that guy, then you'll find it difficult to understand that section, but if you know of friends outside,…it is easy to approach them, you know them, so where we tend to have friends who who doing, have you, who are in the higher level than us… so you interact with your fellow students".

In all, six of those interviewed mentioned tutors to help them work through problems, although two responded negatively to the idea, suggesting they'd rather consult their friends who'd already done Thermodynamics II. In the Council On Higher Education report (2010, p.10), mentioned in Chapter 4.4.2.2 and 4.4.3.1.2, it recommends that students should be actively engaged with their fellow students in and out of the classroom in various activities as "students learn more when they are intensely involved in their education and are required to reflect on their learning", and that peer student tutoring should be encouraged.

In relation to the interviews concerning tutorials, opinions were varied. Some interviewees recommended more problems rather than extra tutorial periods, student I saying that more tutorial periods would help, but student D indicated that students don't attend their tutorial periods a lot of the time anyway so more periods would be a waste of time.

The right approach to studying and the appropriate study time are added requirements for success. Analysis of the study habit survey's twenty nine items, seen in Appendix H, when compared to students' passing the subject only produced one definitive result, although some interesting trends were observed. As indicated in Chapter 4.2.4 study times indicated in the literature vary from around ten to thirty hours per week. A significant finding from the study habit survey was that students who studied three or more hours per week on Thermodynamics had twice the probability of passing as students who studied less. Further, although not a significant finding, it was observed that those who completed all their tutorial problems had a

50% greater chance of passing, as discussed in Chapter 4.2.6.

Much has been studied about various forms of delivery in recent years along with the way that students learn. Various modes of delivery were discussed in Chapter 2.2 and how students learn in Chapter 2.1. In Chapter 4.2.6 students preferred learning styles were investigated via the study habit survey. Whilst not a reliable test due to its simplicity, at 49% as seen in Table 4.8, the majority of students indicated that they preferred a visual style of learning, a figure much lower than the more valid and reliable studies of Felder and Brent (2005, p.61), using their Index of Learning Styles (ILS), at 82%. Visual learners, who are generally predominant in undergraduate engineering classes according to Felder and Brent (2005, p.61), appear to have a higher probability of passing than other types of learners. As mentioned above, students who professed to be visual learners were in the majority in this class and recorded the highest pass rates. Also indicated in Chapter 4.2.6 the majority of teaching is done verbally using lectures, indicating a mismatch of teaching and learning styles, with the auditory learning style only indicated by 6% of students.

Group work, introduced in Chapter 2.2.6, is an area which has become increasingly popular as it can help to build a student's independence and skills. Setting up of the groups was described in Chapters 3.8.1 and 4.1.1. Although seven of the nine students interviewed indicated that they normally study on their own rather than in groups, discussed in Chapter 4.4.2.1, the running of the computer laboratory sessions combined with the tutorial period required students to actively participate in group activities to solve their tutorial problems and construct their spreadsheets according to the assignment instructions on the handouts described in Chapter 3.8.2. Most groups tended to get on with the tasks fairly quickly, but some initial problems arose fairly soon which were dealt with as described in Chapter 4.1.2. Although computer problems continued to plague operations, most groups tended to carry on with the required tasks. Combined group work with computer aided learning was one of the main components of this study and it was successful in that students interacted with each other and shared ideas. No groups appeared to break down from a cooperative viewpoint.

Another aspect of the study that was new to students was the assessment of their peer's spreadsheets. Although there was initially some concern from the students about the process they got on with the task and provided a fair assessment according to the rubrics requirements. This can be seen from the comments made by students on the assessment forms, mentioned in

Chapter 4.1.7.2, as well as the moderation weighting factor for the assessment, described in Chapter 4.1.7.3, being close to one. There were some problems during the peer assessment, also mentioned in Chapter 4.1.7.2 and 4.1.8.1, although these did not hamper the process. It also provided a formative aspect to it, seen by Student D's comment in Chapter 4.1.8.2. Further, the fact that several groups were prepared to reassess assignment 2, described in Chapter 4.1.8.4, showed that they took an interest in the process.

Concerning study techniques, specifically note taking introduced in Chapter 2.1.8 and discussed in Chapter 4.2.6, this was investigated both in the interviews and via the study habit survey. Student C said:

> "I just take the key points as to what was covered in class and then the certain
> information that I may have realized is not in the notes, then that I may have taken…".

Of the other students interviewed, only one indicated that they would partially rewrite their notes later because the library notes contained all the information they required, several others also indicating that the library notes were generally sufficient. Only 25% of the students surveyed indicated that they rewrote their class notes later. It was not found to be a significant factor for achieving success, as mentioned in Chapter 4.2.6.

5.3 Sub-Question 2 – What problems do students studying Thermodynamics experience and why?

Much of the data relating to the problems that students experience with thermodynamics came from the interviews, although some problems were highlighted from the student study habit survey, as well as the concept test. As mentioned in Chapter 2.4.1 to 2.4.4 some problems relate to the subject, whilst others arise from related areas, such as resources and further, the teaching and learning itself. Many of the problems faced by students are not necessarily exclusive to thermodynamics, but run right through their other subjects. Some of the problems have been mentioned earlier in this chapter. Others were discussed in Chapter 4 and are highlighted here.

5.3.1 Subject related problems

One of the most fundamental requirements of Thermodynamics is a good understanding of the terminology and a thorough grasp of the concepts. Only once one has a grasp of these do all the formulas, calculations and graphs begin to make sense. Further the laws, systems and an appropriate sign convention need to be followed vigorously. These will be discussed in the following paragraphs.

One of the most fundamental problems, highlighted in Chapter 2.4.1and discussed in Chapter 2.3.1, is the conceptual nature of Thermodynamics. An understanding of these concepts was required to successfully complete the Concept Test, as indicated in Chapter 4.3. Heywood (2000, p. 203) suggests that many students in higher education find it difficult to learn concepts. Of concepts, Student E said:

> "concepts were a bit I still, I still struggle with – to, um you you know, to to come to terms with them, understand like".

Similarly, student D said:

> "little things like ah basics, then they won't get that basic and then they comes in test 1 that that little thing that they missed was very important".

On the other hand, student H said of the concepts:

> "you see the concepts, the concepts are not that difficult – you see the calculation part, you see from the steam plant onwards…",

suggesting that the calculation parts were more of a problem, as did student A, when he said:

> "I can understand the notes, um, the only thing that that it lags a bit is maybe the calculations side, but I mean that I can pick up from Eastop....".

Student C said that he had spent excess time studying in the beginning but:

> "Due to understanding the first section it has enabled me to grasp the the the latter sections quicker because the first few sections were actually the basis of the work done in the latter latter sections".

The ability of the students to understand and use the laws, analyse systems and utilize a sign convention appropriately was investigated by students answering the questions posed in the concept test. The analysis of the concept test was dealt with in detail in Chapter 4.3. A summary of the findings is detailed here.

The adoption and careful use of a sign convention is critical in Thermodynamics, specifically so in the Concept Test since two different formats were available to use. This aspect was described in detail in Chapter 4.3.2. Generally, the students who used the notes adopted convention fared slightly better in the test overall. Considering the first page (Appendix D: Concept test page 1)

involving the recognition of an adiabatic compression process, less than half got the work quantity and flow direction correct. Students who recognised the type of process, mentioned above, fared slightly better with just over half getting it right. Concerning the use of the first law to answer the last question, c, only about a quarter got it correct. As described in Chapter 4.3.2, similar studies by Meltzer (2004a, pp.1440-1441) and Loverude, Kautz and Heron (2002, p.140), obtained similar results, although their students had slightly lower success interpreting the diagram. Meltzer also used the same test as part of an interview, students faring less well in that test than the written test.

The second page (Appendix D: Concept test page 2) required an understanding of cycles and the use of the first law, together with the appropriate sign convention. Concerning heat energy flow direction, as discussed in Chapter 4.3.3.2 just over two thirds chose incorrectly compared to Meltzer (2004a) at between 40% and 60%. Again use of the first law was required to analyse the problem, with just over 50% getting it correct, utilising either sign convention. This was less than Meltzer (2004a, p.1436) at 85%.

The third and fourth pages of the Concept Test (Appendix D: Concept test page 3 and Appendix D: Concept test page 4), discussed in Chapters 4.3.3.3 and 4.3.3.4 respectively, were generally simpler problems in that they mostly involved recognition of the parts that make up closed and open systems, with about 90% getting the answers correct. However, when it comes to recognition as to where heat and work are located on the diagrams between three and eight percent of students chose incorrectly. It is something also observed in tests where students do not differentiate between the two different forms of energy and will substitute one for the other.

Motivation was introduced in Chapter 2.1.6 and discussed further in Chapter 4.4.2.4. As mentioned in Chapter 4.4.2.4 students often don't initially see a need for Thermodynamics and are de-motivated from the beginning. Further, as was mentioned in Chapter 2.3.5, the format of presentation is typically presented in a linear fashion requiring students to grasp each new concept before the next can be mastered, highlighted by interview student F in Chapter 4.4.2.5. Failing to grasp these as one moves along, typically fairly rapidly, can also be de-motivating as Student A indicated from the interview, as seen in Chapter 4.4.2.4. It is appreciated that this subject is well known locally and internationally as a somewhat "difficult subject" that students have to work hard at, due to its conceptual nature at the start as highlighted in Chapter 2.3.1. If intrinsic motivation is what is desired to generate a positive attitude towards learning, then the

right environment needs to be created. Only once this is created will one get the right attitude from students who may then put in the required effort and discipline to acquire the right approach to study skills. As can be seen of attendance figures in Table 4.1, the attendance of the computer laboratory periods declined as the semester moved on, with only 67% of the class attending the second assessment session for assignment 2.

Students ability to read and interpret simple instructions, either verbally or written or both, was a concern. However, only one student interviewed commented on use of English, saying:

> "it's a bit eh hard for us to to actually understand the that particular section eh at the first time we we were being exposed to it, eh considering the the language…, but I I think eh the language is actually affecting us",

although he went on later to say that it was not necessarily the English, but the language of Thermodynamics itself that was the problem.

During the interviews all the interviewees were asked what they thought other students doing thermodynamics did to do well and also what others did wrong, as seen in Appendix I. Student D said:

> "…they don't give time for the subject…, most of the time they don't get the basics, of Thermos. And without the basics aich, so most of the time its time. What they realise they did in, let's say they are at test one, and then they fail and then you...ask…"what went wrong" and thing is "eh, I didn't understand this, why". Cause you didn't know that, and then its "Ok, so I need to know the basics first", then to give it time to do it and then to understand it. Then, from there and then on, then you'll find it test two, it's much easy".

One may argue that this implies that a time of reflection is required, as described in Kolb's Learning Cycle model, seen in Chapter 2.1.5.

Student C, of other students' problems, said:

"…they panic and they don't study and last minute they start asking questions on how to do that and not understand the fundamentals of that section itself, and they want to know how to calculate a certain problem, without understanding the dynamics of the problem itself".

5.3.2 Other problems

One of the other issues, not directly related to Thermodynamics itself but having a major impact on students, is finances in that students cannot afford the tools they need to complete their studies, let alone for living and transport. This was discussed in detail in Chapter 4.4.3.2.

Another problem experienced, not directly related to the subject itself, but having a direct impact on success of the computer intervention, was the student's computer skills knowledge, both from the operating side and the programming side. In addition there were problems with the computers themselves, both from availability and access, as mentioned by student E in Chapter 4.4.3.2. Many delays were caused by things such as viruses brought in by the students or by others with access to the open computer laboratories used in the study. Also the issue of availability out of the lecture times was problematic as the number of computers is limited and access to the laboratories is often only available to students after hours, resulting in some students being unable to access them due to transport problems. These and other problems were discussed in detail in Chapter 4.1.1.1. Another area of concern for students and staff alike, although not part of the study but an important aspect none-the-less is safety and security in and around the Campus after hours.

The computer skills problem related to both the use of, and the operation of, the computers. It also related to the spreadsheet program used, Excel. Many of the observed problems picked up from the Researcher assessing the assignments during moderation were discussed in Chapter 4.1.7.2 and 4.1.8.2. Although all students had completed a subject, Computer Skills I or Computer and Programming Skills I (Durban Institute of Technology, 2006a, pp.10, 15), depending on their first registration, there were several issues about their being able to apply the knowledge gained in that subject to the computer intervention assignments in the study. Many did not appear to understand the intricacies of things like:

- saving files with new names
- being very clear and concise when entering data
- not being able to perform basic engineering mathematical functions in spreadsheets, most notably not being able to enter a formula to raise a number to a power, mentioned in Chapter 4.1.2
- unfamiliarity with "read only" files and what to do with them.

The computer skills acquired from their introductory subject did not appear to develop all the abilities expected of the students when applying their computer knowledge gained to other subjects, whether for operation or programming, since it has been taken over by a servicing department. As the Researcher has taught the computer skills subject in the Department previously, specifically the spreadsheet section, he has firsthand knowledge of the type of operations taught to students in that section. During the first practical session the Researcher observed students both adding and averaging columns of numbers, the latter one not required at all in either of the assignments. This was highlighted in the lecture set aside specifically to bring student problems up on any aspect related to the assignments or spreadsheets, as detailed in Chapter 4.1.2. The abilities of students to utilise spreadsheets appropriately, specifically in Mechanical Engineering applications has been an ongoing concern to the Department. In this respect, the Mechanical Engineering Department needs to have more input in the curriculum design of the subject in the re-curriculation, which is currently on hold. This problem was also highlighted in the external programme evaluation conducted in September 2009 (Zawilska, 2009, p.6) in preparation for the ECSA accreditation visit due in 2010. It is often said that students do not appear to be able to transfer the skills learnt in one context to those of another. This appeared to be so with the use of computers when used to analyse thermodynamics problems.

A major cause for concern, not only in Thermodynamics but within the Department and across the institution is cheating. This has been on the increase in recent years, as seen in the statistics in Appendix V. The main areas have been, copying and plagiarism of practicals, detailed in Chapter 4.4.3.1.1, having unauthorised documentation in examinations, and increasingly the misuse of cell phones, mentioned in Chapter 4.2.2. A summary of student tribunals for the last seven years appears in Appendix V, examination cheating increasing dramatically in 2010. As mentioned previously some of the cases mentioned in Appendix V later involved students from this study, mainly with copying and plagiarism of practicals.

5.4 Sub-Question 3 – Did the intervention improve pass rates?

To quantify and evaluate what effect the intervention had it was necessary to compare data. As the tests and semester examination were the only sources of data to evaluate they were considered in two different ways. The method is described in Chapter 3.6 and the analysis carried out in Chapter 4.5.

First the semester tests, test 1 (part lectures and part computer intervention) and test 2 (all lectures), were compared using a Paired Sample T-test, the results appearing in Table 4.18. The results of this test indicated that the scores from the two tests were moderately different, with a correlation between the two tests of 0,448. It also indicated that the students generally did better in the second test. A further test was carried out on the test scores, the Wilcoxon Signed-Rank Test, whose results appear in Table 4.19. This confirmed the previous result.

Next the test results from the previous five semesters were used as a control group and compared to the two intervention semester tests. The justification in doing this was detailed in Chapter 4.5.1. A Oneway ANOVA test was performed on all six combined semester test 1 and test 2 scores separately, comparing the test 1's and test 2's, the results appearing in Appendix T. It was found, with the exception of set five (the reason indicated in Chapter 4.5.4), that there was little difference between the test 1 scores of previous semesters and test 2 scores of previous semesters. A further test, a Post Hoc Tukeys Test, detailed in Chapter 4.5.4, was done confirming the above mentioned result, that there was little difference in the test scores between semesters.

This indicates that, although students did better in the second test, it was not necessarily as a result of the computer intervention, since historically students had done better in the second test, where application of the basics learnt in the work covered by test 1 is used to analyse systems, etc. The conclusions drawn about the test score comparisons for the intervention semester appear in Chapter 4.5.3 and the conclusions drawn about the test score comparisons between the intervention semester and previous semesters appear in Chapter 4.5.5. Thus an overall increase in pass rate was not achieved as compared to previous semesters, and a higher pass rate in Test 2 compared with Test 1 in the intervention semester could not necessarily be attributed to the computer intervention.

However, one cannot dismiss the fact that the computer intervention may have helped students to understand the basic concepts of Thermodynamics better, hence the better performance in the second test, as seen in Table 4.17. As discussed in Chapter 4.1.5.4 the effect size of this style of intervention, using the formula for "overall effect size" applied by Hattie, Biggs and Purdie (1996, p.111) was 0,13. Although positive, it is lower than their computer-assisted instruction effect size of 0,31 indicated by Hattie, Biggs and Purdie (1996, p.115), but with no details as to

what type of computer-assisted instruction being indicated further comparison could not be drawn.

Student B said of the computer assignments:

> "looking at the computer exercises, I think the computer exercises was the one of the support for this semester where you can actually do tuts practically, practically so that you can see how the process operates",

suggesting that the intervention, although it did not improve pass rates, may have had a positive impact on students by helping them to visualize the processes. Since the majority of students indicated a preference for visual learning, discussed earlier in Chapter 5.2, this could have helped the students understanding of the theory.

5.5 Limitations of the study

The study was planned as a case study, as discussed in Chapter 3.1, being a once off intervention to investigate the usefulness of spreadsheets as a teaching and learning tool. Whilst several different methods of information gathering were used to obtain data, the study itself was limited to one class over a limited time period at one institution. This thus limited the generalizability of the study.

Further, the Researcher was focused initially more on how the test results proved the efficacy of the delivery mode, a Positivist approach. However, it was discovered that the process had many contributing factors that impacted on the study, some of which were beyond the control of the Researcher. Also, because of the different data gathering methods used and the many factors considered that may have an effect on student success, trying to consider them together was at times overwhelming, limiting the ability to isolate what factors may have had a positive effect. Designing a study to isolate each factor or area considered and to investigate their influence on student learning could prove a useful study. Some questions that arose during the study and warrant further investigation are detailed in Chapter 5.7.

5.6 Conclusions

Although the pass rate did not improve for the intervention semester, as hoped, the style of presentation and its associated assessment methods could be deemed to have been successful in achieving its aim and that alternative methods of teaching and learning can and should be used. In attempting to answer the primary question posed in Chapter 2, above Chapter 2.1— "How

does delivery affect student understanding?" —the Researcher can only say that from all the evidence collected during this study it did not allow one to draw any conclusion about how delivery affects students understanding. Although it would be of interest to follow up on the study group to see their success rates in subsequent follow-on subjects compared with others who did not participate in the study it would be difficult to determine whether it was the intervention as a whole with its more constructivist ways of learning, or whether it was specific features of it, such as use of computers, or use of groups or peer assessment that influenced or otherwise affected a students understanding of Thermodynamics.

It has to be acknowledged that certain logistics were not administered wisely, including:
- not enough assistants during laboratory sessions, further exacerbated when three staff members backed out only minutes before the first assessment began, leaving the Researcher very little backup during this important assessment session
- not being able to test all the hardware beforehand due to the short preparation time prior to the start of the project
- students' need to have some sort of incentive for the extra efforts they put in due to the various research tasks assigned.

Also the number of tasks as well as the new styles of learning given to students during the course of this study in the time available was probably too high. If one considers Biggs' (2003, p.18) 3P model of Presage, Process and Product, which consider respectively what happens "before learning takes place…during learning [and] the outcome learning", something the Researcher has to admit he was not aware of at the time, the elements were there but not perhaps as clearly defined as they should have been before the start of the intervention. Phillips, McNaught, & Kennedy (2010, p.2498) have built on the work of "Biggs…(3-P) model (1989)", "Laurillard's…framework (2002)" and the "Framework… by Bain (1999)" to develop what they believe is a "largely pedagogically neutral" (ibid, p.2502) learning framework taking into account the "Learning Environment, Learning Processes and Learning Outcomes", or "LEPO framework". The two key players within their framework, as with Biggs 3P model, are the teacher and the student, who interact with all three parts of the framework. Using the LEPO framework as a tool at the starting point may have helped to highlight unexpected issues that arose along the way, together with a plan of action to overcome them, and should be considered early in the design of any future interventions. Whilst the learning outcomes of the subject are well documented in Appendix W and circulated at the start of the semester, the learning

outcomes of the various learning processes used in the study could have been highlighted to students more specifically. Also an analysis of the learning environment and processes, together with problems that might arise and possible solutions may have reduced the problems that did occur. A pilot study with a group of students would also have helped to highlight problems that did arise along the way.

Although this study did not provide conclusive evidence about how delivery affects students' understanding of Thermodynamics it did assist the Researcher to look into the problems that students face, not only in the classroom but also problems that they face within the tertiary education environment. It has also broadened the Researcher's understanding of the problems faced in tertiary education.

5.7 Questions for further investigation

Several questions arose during this study. They have been grouped below into categories relating to aspects of the study.

5.7.1 Teaching/Learning

What style of delivery/scaffolding would enhance students understanding? (Chapters 5.1.1, 5.6)

What effect would a global introductory overview of the subject have on conceptual understanding? (Chapters 2.4.1, 4.4.3.1.2)

What effect does group study have? (Chapters 2.2.6, 5.2)

Do students' learning styles and study habits change with task, subject, level, age? (Felder & Brent, 2005, p.63)

What computer skills do our students have and need? (Chapter 5.5)

What effect does cell phone use have on students learning? (Chapters 4.2.2, 4.2.6)

Why do students cheat? (Chapters 3.9.2, 4.2.2, 4.4.3.1.1, 5.5)

What effect does reading skills level have? (Chapter 5.4.4)

How well do our students understand the terminology of thermodynamics? (Chapters 2.3.1, 4.1, 4.4.2.6)

What are the problems students have with the writing of the practical reports? (Chapter 4.4.3.1.1)

How effective are learner guides? (Chapters 4.1.5, 4.2.4, 4.4.3.1.1)

Does lack of exposure to appropriate industrial plant affect learning? (Chapters 2.4.1, 4.2.5,

4.4.2.3)

Why don't students attend their tutorials? (Chapter 5.3)

Are other engineering discipline students any different to mechanical engineering students?

5.7.2 Library

How effective is the library introductory course? (Chapter 4.2.3, 5.1.2)

How effective are our students in the library? (Chapter 4.2.3, 5.1.2)

What use do our students make of the library services? (Chapter 4.2.3, 5.1.2)

REFERENCES

Atherton, J. S. (2002a). *Heterodoxy: Learning styles don't matter.* Retrieved June 14, 2007, from http://www.doceo.co.uk/heterodoxy/styles.htm.

Atherton, J. S. (2002b). *Heterodoxy: What's wrong with surface learning.* Retrieved June 28, 2007, from http://www.doceo.co.uk/heterodoxy/surface.htm.

Atherton, J. S. (2005a). *Learning and Teaching: Deep and Surface learning.* Retrieved June 7, from http://www.learningandteaching.info/learning/deepsurf.htm

Atherton, J. S. (2005b). *Learning and Teaching: Cognitive theories of learning.* Retrieved February 28, 2007, from http://www.learningandteaching.info/learning/cognitive.htm

Atherton, J. S. (2005c). *Learning and Teaching: Motivation.* Retrieved August 28, 2007, from http://www.learningandteaching.info/learning/motivation.htm

Atherton, J. S. (2005d). *Learning and Teaching: Experiential Learning.* Retrieved June 5, 2007, from http://www.learningandteaching.info/learning/experience.htm

Atherton, J. S. (2005e). *Learning and Teaching: Constructivism in learning.* Retrieved February 28, 2007, from **http://www.learningandteaching.info/learning/constructivism.htm**

Atherton, J. S. (2005f). *Learning and Teaching: Problem Based Learning.* Retrieved February 28, 2007, from http://www.learningandteaching.info/teaching/pbl.htm

Atherton, J. S. (2008). *Heterodoxy: Learning styles don't matter.* Retrieved November 3, 2009, from http://www.doceo.co.uk/heterodoxy/styles.htm

Atherton, J. S. (2010a). *Learning and Teaching; Bloom's Taxonomy.* Retrieved November 26, 2010, from http://www.learningandteaching.info/learning/bloomtax.htm

Atherton, J. S. (2010b). *Learning and Teaching; What works and what doesn't.* Retrieved November 26, 2010, from http://www.learningandteaching.info/teaching/what_works.htm

Baron, S., Patterson, A., & Harris, K. (2006). Beyond technology acceptance: understanding consumer practice. *International Journal of Service Industry Management, 17*(2), 111-135.

Barrett, A. (2005). The Information-Seeking Habits of Graduate Student Researchers in the Humanities. *The Journal of Academic Librarianship*, 3*1*(4), 324-331.

Beylefeld, A. A., Joubert, G., Jama, M. P., & de Klerk , B. (2003). Lecturers, Students and Community Members sharing the Responsibility of Assessing Project-based Poster Presentations. *S.A.J.H.E./S.A.T.H.O.*, *17*(2), 5-12.

Biggs, J. (1999). Teaching for Quality Learning at University. Buckingham: SRNE & OUP.

Biggs, J. (2003). *Teaching for quality learning at university: What the student does.* (2 ed.). Mainhead, UK: Open University Press.

Boehler, M. L., Schwind, C. J., Folse, R., Dunnington, G., Markwell, S., & Dutta, S. (2001). An evaluation of study habits of third-year medical students in a surgical clerkship. *The American Journal of Surgery, 181*(2001), 268-271.

Boomgaard, M. (2009, March 29 2009). MXit-can you 'bare' it? *Sunday Tribune,* p. 14.

Boud, D. (1989). The role of self-assessment in student grading. *Assessment and grading in Higher Education*, *14*(1), 10.

Boud, D. (1995). Assessment and Learning: Contradictory or Complimentary? In P. Knight (Ed.), *Assessment for Learning in Higher Education* (pp. 35-48)*.* London: Kogan Page.

Boud, D., & Feletti, G. (Eds.). (1997). *The Challenge of PROBLEM-BASED LEARNING* (2 ed.). London: Kogan Page.

Bourne, J, Brodersen, A. & Dawant, M. (Eds.) (1995). *The Influence of Technology on Engineering Education*. Boca Raton: CRC Press, Inc.

Breier, M. (Ed.). (2001). Curriculum Restructuring in Higher Education in post-apartheid South Africa. Cape Town: UWC Education Policy Unit.

Brookfield, S. D. & Preskill, S. (1999). *Discussion as a Way of Teaching*. Buckingham: The Society for Research into Higher Education and Open University Press.

Brown, P. S., & Gould, J. D. (1987). An Experimental Study of People Creating Spreadsheets. *ACM Transactions on Office Information Systems*, *5*(3), 258-272.

Brown, S, Race, P. & Rust, C. (1995). *500 Tips on Assessment*. London: Kogan Page Limited.

Brown, S, Race, P. & Smith, B. (1995). Using and Experiencing Assessment. In P. Knight (Ed.), *Assessment for Learning in Higher Education,* 75-85. London: Kogan Page Limited.

Case, J., & Marshall, D. (2004). Between deep and surface: procedural approaches to learning in engineering education contexts. *Studies in Higher Education*, *29*(5), 605-615.

Chapman, A. (1995). *Businessballs.* Retrieved June 28, 2007, from http://www.businessballs.com/vaklearningstylestest.htm

Chen, T. (1997). A measurement of the resource utilization efficiency of university libraries. *International Journal of Production Economics*, *53*(1997), 71-80.

Chickering, A., & Reisser, L. (1993). *Education and Identity.* San Francisco: Jossey Bass.

Chislett, V., & Chapman, A. (2005). *free VAK learning styles test.* Retrieved June 28, 2007, from **http://www.businessballs.com/vaklearningstylestest.htm**

Christensen, R. (1996). Analysis of Variance, Design and Regression, Applied statistical methods. Bungay: Chapman and Hall.

Cloete, N. & Maassen, P. (2002). The Limits of Policy. In N. Cloete, R. Fehnel, P. Maassen, T.

Moja, H. Perold & T. Gibbon (Eds.), *Transformation in Higher Education: Global Pressures and Local Realities in South Africa*. Cape Town: Juta and Co. & CHET.

Coffield, F., Moseley, D., Hall, E., & Ecclestone, K. (2004a). *Learning styles and pedagogy in post-16 learning A systematic and critical review.* Retrieved February 1, 2006, from https://www.lsda.org.uk/cims/order.aspx?code=041543&P=041543PD&action=pdfdl&src=XOWEB&u=a

Coffield, F., Moseley, D., Hall, E., & Ecclestone, K. (2004b). *Should we be using learning styles? What research has to say to practice.* Retrieved February 1, 2006, from **https://www.lsda.org.uk/cims/order.aspx?code=041540&P=041540PD&action=pdfdl&src=XOWEB&u=a**

Cohen, L., Manion, L., & Morrison, K. (2000). *Research Methods in Education* (5th ed.). London: Routlidge Falmer.

Cosser, M., & Letseka, M. (c. 2009). Student Retention and Graduate Destination: Higher Education and Labour Market Access and Success [Electronic Version], 1-9. Retrieved 2010/12/22 from www.hsrcpress.ac.za.

Council On Higher Education. (2002). Occasional Paper 1 National and Continental Human Resource Development Initiatives: Challenges for Higher Education. In course pack notes, Curriculum Development Module, UKZN, 2005.

Council On Higher Education. (2003). *Improving Teaching and Learning Resources. (Draft).* Retrieved November 17, 2009, from http://che.octoplus.co.za/documents/d000087/

Council On Higher Education. (2004a). South African Higher Education in the first decade of democracy. Pretoria: CHE.

Council On Higher Education. (2004b). *Improving Teaching & Learning Resources, Resource No. 1: PROGRAMME PLANNING, DESIGN & MANAGEMENT*. Retrieved November 17, 2009, from http://che.octoplus.co.za/documents/d000087/

Council On Higher Education. (2004c). *Improving Teaching & Learning Resources, Resource No. 2: PROGRAMME PLANNING, DESIGN AND MANAGEMENT*. Retrieved November 17, 2009, from **http://che.octoplus.co.za/documents/d000087/**

Council On Higher Education. (2005). *Communiqué on plans and activities for 2005/2006*. Pretoria: CHE

Council On Higher Education. (2010). *South African Survey of Student Engagement Focusing the Student Experience on Success through Student Engagement*. Retrieved 2010/10/31. from http://www.che.ac.za/documents/d000208/SASSE_2010.pdf.

Cox, B. (1994). *Practical Pointers For University Teachers*. London: Kogan Page.

Department of Higher Education and Training (DHET). (2010). *Strategic Plan 2010/11 to 2014/15 and Operational Plans for the 2010/11 Financial Year*. Retrieved August 16, 2010, from http://www.pmg.org.za/files/docs/100310HETStratPlan_0.pdf

Denscombe, M. (2003). *The Good Research Guide for Small Scale Research Projects.* Maidenhead: Open University Press.

Durban Institute of Technology. (2002). *Rule Book for Students 2003*. Durban Institute of Technology (DIT, now DUT).

Durban Institute of Technology. (2005a). Faculty of Engineering, Science & the Built Environment 2005. Department of Mechanical Engineering. Durban Institute of Technology. (DIT, now DUT).

Durban Institute of Technology. (2006a). Faculty of Engineering, Science & the Built Environment 2006. Department of Mechanical Engineering. Durban Institute of Technology. (DIT, now DUT).

Durban Institute of Technology. (2006b). *Rule Book for Students 2006.* Durban Institute of Technology (DIT, now DUT).

Durban University of Technology. (2010). *Rule Book for Students 2010.* Durban University of Technology.

Eastop, T. D. & McConkey, A., (1993). *Applied Thermodynamics for Engineering Technologists*. New York: Longman Scientific & Technical/John Wiley & Sons, Inc.

Ehrlich, P. (2002). How do we know if we are doing a good job in Physics Teaching? *American Journal of Physics, 70*(1), 24-29.

Emenalo, S. I. (1989). Students' study problems. *International Journal of Mathematical Education in Science and Technology, 20*(1), 13-19.

Entwistle, N. (1988). Styles of Learning and Teaching An Integrated Outline of Educational Psychology for Students, Teachers and Lecturers. London: David Fulton.

Erdamar, G. C., Demirel, H. (2009). The library use habits of student teachers. *Procedia Social and Behavioural Sciences, 1*(2009), 2233-2240.

Esterberg, K. G. (2002). *Qualitative Methods in Social Research.* USA: McGraw-Hill Higher Education.

Falchikov, N. (1995). Improving Feedback to and from Students. In P. Knight (Ed.), *Assessment for Learning in Higher Education* (pp. 157-166). London: Kogan Page.

Felder, R. M., & Silverman, L. K. (1988). Learning and Teaching Styles in Engineering Education. *Journal of Engineering Education,* 78(7), 674-681.

Felder, R. M., & Brent, R. (1996). *Navigating the Bumpy Road to Student-Centered Instruction*. Paper presented at the Workshop on Effective Teaching of Engineering and Science, 20 September 1999.

Felder, R. M., & Soloman, B. A. (2005). *Learning styles and strategies.* Retrieved December 9, 2009, from **http://www.ncsu.edu/felder-public/ILSdir/styles.htm**

Felder, R. M., & Brent, R. (2005). Understanding Student Differences. *Journal of Engineering Education,* 94(1), 57-72.

Field, A. (2000). Discovering Statistics using SPSS for Windows, Advanced Techniques for the Beginner. Trowbridge: SAGE Publications.

Fink, A., & Kosecoff, J. (1985). *How to Conduct Surveys*. Newbury Park: Sage Publications, Inc.

Fleming, A. (2005). *Learning styles.* Retrieved February 1, 2006, from unknown.

Fleming, A. (2008). *Learning styles.* Retrieved October 31, 2009, from **http://cipd.co.uk/sublects/manddev/general/lrngstyles.htm**

Fleming, N. D. & Mills, C. (1992). Not Another Inventory, Rather a Catalyst for Reflection. *To Improve the Academy*, 11 1992, 137-155. Retrieved October 31, 2009, from http://www.vark-learn.com/documents/not_another_inventory.pdf

Fleming, N. & Baume, D. (2006) Learning Styles Again: VARKing up the right tree! *Educational Developments, SEDA Ltd*. (7.4), 4-7. Retrieved October 31, 2009, from http://www.vark-learn.com/documents/Educational%20Developments.pdf

Frank, E. (2006). An investigation of whether the introduction of an E-mastery system for Quantity Surveying Students at the Durban Institute of Technology improves key competencies. Unpublished master's thesis, University of KwaZulu-Natal, Durban.

Gillham, B. (2000). *Case Study Research Methods*: Cornwall: T J International Ltd.

Greenway, R. (2007). Experiential Learning articles and critiques of David Kolb's theory. Retrieved June 5, 2007, from unknown.

Grundy, S. (1987). *Curriculum: Product or Praxis?* London: Falmer Press.

Guba, E. G. (Ed.). (1990). *The Paradigm Dialog.* USA: Sage Publications.

Hattie, J., Biggs, J., & Purdie, N. (1996). Effects of Learning Skills Interventions on Student Learning: A Meta-Analysis. *Review of Educational Research*, *66*(2) (Summer, 1996), 99-136.

Hay, H. R., & Marais, F. (2004). Bridging Programmes: gain, pain or all in vain. *South African Journal of Higher Education, 18*(2), 59-75.

Heywood, J. (2000). *Assessment in Higher Education. Student Learning, Teaching, Programmes and Institutions*. England: Jessica Kingsley Publishers Ltd.

Higher Education Act 1997. Government Gazette No. 101 of 1997, (1997). Retrieved June 4, 2004, from http://www.showprogfortransformationofhed.htm/

Higher Education Practice 1. (2004). (HEP1) Module. Durban Institute of Technology (now DUT).

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and Achievement in

Problem-Based and Inquiry Learning: A Response to Kirschner, Sweller, and Clark (2006). *EDUCATIONAL PSYCHOLOGIST, 42*(2), 99-107.

Huba, M. E. & Freed, J. E. (2000). *Learner-Centered Assessment on College Campuses Shifting the Focus from Teaching to Learning*. Needham Heights: Allyn and Bacon.

Iqbal, H. M., Sohail, S., Shahzad, S. (2009). Learning and study strategies used by university students in Pakistan. *Procedia Social and Behavioural Science*, *2*(2010), 4717-4721.

Jarvis, P. (1999). *The Practitioner-Researcher Developing Theory form Practice*. San Francisco: Jossey-Bass Publishers.

Joel, R. (1987). *Basic Engineering Thermodynamics* (4th ed.). Hong Kong: Longman Scientific and Technical.

Joel, R. (1996). *Basic Engineering Thermodynamics* (5th ed.). Adison Wesley Longman Ltd.

Jong, I.-C., Couvillion, R. J., & Roe, L. A. (2002). Paper presented at the Proceedings of the 2002 American Society for Engineering Education Annual Conference and Exposition. *Meandering Road from Dynamics to Thermodynamics and Vice Versa: What is Work?*

Jordan, P. J. (2004). A Spreadsheet-Based Method for Thermal Radiation Calculations. *The International Journal of Engineering Education*, *20*(6), 991-998.

Kanny, K., & Thurbon, G. A. (2005). Policy for the accreditation of Technikon Programmes in Engineering : National Diploma:Engineering and B Tech Engineering Degrees for the purpose of Registration. Durban: DUT (formerly DIT).

Kirschner, P.A., Sweller, J. & Clark, R. E. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *EDUCATIONAL PSYCHOLOGIST*, *41*(2), 75-86.

Koob, J. J., & Funk, J. (2002). Kolb's Learning Style Inventory: Issues of Reliability and Validity. *Research on Social Work Practice*, 293-308. Retrieved June 5, 2007, from unknown.

Kuh, G. D. (2010). Maybe Experience Really Can Be the Best Teacher [Electronic Version]. *The Chronicle of Higher Education*. Retrieved 2010/12/21 from http://chronicle.com/article/Maybe-Experience-Really-Can-Be/125433/.

Lam, D. Ardington, C. Branson, N. Goostrey, K. Leibbrandt, M. (2010). *Credit Constraint and the Racial Gap in Post-Secondary Education in South Africa*. Dallas: Population Association of America. Retrieved December 5, 2010, from www.caps.uct.ac.za

Lawson, D. (2004). The Blackbody Fraction, Infinite Series and Spreadsheets. *The International Journal of Engineering Education*, *20*(6), 984-990.

Leedy, P. D. (1997). *Practical Research, Planning and Design* (6th ed.): New Jersey: Prentice Hall, Inc.

Letseka, M., & Maile, S. (2008). *High University drop-out rates: a threat to South Africa's future* (Policy Brief). Pretoria: Human Sciences Research Council (HSRC). Retrieved 2010/12/22 from http://www.hsrc.ac.za/Document-2717.phtml

Lipscomb, T. J.,Totten, J. W.,Cook, R. A.& Lesch, W.. (2005). Cellular phone etiquette among college students. *International Journal of Consumer Studies, 31*(2007), 46-56.

Locke, L. F., Silverman, S. J., & Spirduso, W. W. (1998). *Reading and Understanding Research*: California: Sage.

Loverude, M. E., Kautz, C. H., & Heron, P. R. L. (2002). Student Understanding of the First Law of Thermodynamics. *American Journal of Physics, 20*(2), 137-148.

Luckett, K., (ed). (1995). Curriculum Development: Reflecting on our practice. Paper presented at the South African Association for Academic Development (SAAAD).

Martens, R. L., Gulikers, J., & Bastiaens, T. (2004). The impact of intrinsic motivation on e-learning in authentic computer tasks. *Journal of Computer Assisted Learning*, *20*(5), 368-376.

Maurice, S. A., & Day, R. L. (2004). A Spreadsheet Method for Promoting Learning in a Non-Supervised Testing Environment. *International Journal of Engineering Education*, *20*(6), 958 - 965.

McKenna, S. (2003). Changing discourses of academic development at a South African technikon 1991 to 2002. *South African Journal of Higher Education, 17*(2), 60-67.

McKenna, S. (c. 2003). Paradigms of Curriculum Design: Implications for South African educators. In HEP1 (2004), session 9: Curriculum Development coursepack notes, DIT (now DUT).

Mehl, M. C., & Sincliar, A. J. L. (1993). Defining a context for CAI: In quest of educational reality. In R. C. Lippert (Ed.), *Computer-based Education and Training in South Africa,* 3-14. Pretoria: J.L. van Schaik.

Meltzer, D. E. (2004a). Investigation of students' reasoning regarding heat, work, and the first law of thermodynamics in an introductory calculus-based general physics course. *American Journal of Physics*, *72*(11), 1432-1446.

Meltzer, D. E. (2004b). Paper presented at the Physics Education Research Conference. *Student Learning in Upper-Level Thermal Physics: Comparisons and Contrasts in Introductory Courses*. Retrieved December 21, 2010, from http://books.google.co.za/books?hl=en&lr=&id=V0LJyTat3goC&oi=fnd&pg=PA31&dq=Thermodynamics+1st+law+spreadsheets&ots=bgstt1bHHq&sig=wv8CKhtPQMXndDEQyS6d0QTt6Sk#v=onepage&q&f=true.

Miller, R. L., Acton, C., Fullerton, D. A., & Maltby, J. (2002). *SPSS for Social Scientists*. China: Palgrave Macmillan.

Mindham, C. (1998). Paper presented at the Staff and Educational Development Association (SEDA Paper 102). *Peer assessment: Report of a project involving group*

presentations and assessment by peers.

Ministry of Education. (2004). *A New Funding Framework: how government grants are allocated to public Higher Education Institutions*. Retrieved January 10, 2006, from **www.education.government.za.content.docs**

Morphew, V. N. (2002). Web-Based Learning and Instruction: A Constructivist Approach. In M. Khosrow-Pour (Ed.), *Web-Based Instructional Learning*, IRM Press.

Mulder, J. C. (1987). *Statistical Techniques in Education*. Pretoria: HAUM Educational Publishers.

Murphy, E. (1997a). *Constructivist Learning Theory.* Retrieved March 30, 2006, from http://www.cdli.ca/~elmurphy/emurphy/cle2b.html

Murphy, E. (1997b). *Characteristics of Constructivist Learning and Teaching.* Retrieved March 30, 2006, from http://www.cdli.ca/~elmurphy/emurphy/cle3.html

Nair, P. A. P. (2002). A theoretical framework for an assessment programme encompassing further education training: remedy for educational wastage? *South African Journal of Higher Education, 16*(2), 94-103.

Neuman, W. L. (2000). *Social Research Methods* (4th ed.). Needham Heights MA: Allyn and Bacon.

Ngo, C. C., & Lai, F. C. (2003). An Online Thermodynamics Courseware [Electronic Version]. *Wiley Periodicals, Inc.*, 11, 75-82. Retrieved 2011/01/04 from www.interscience.wiley.com.

O'Brien, H. L., & Symons, S. (2007). The information behaviors and preferences of undergraduate students. *Research Strategies, 20*(2007), 409-423.

Oke, S. A. (2004). Spreadsheet Applications in Engineering: A Review. *The International Journal of Engineering Education*, *20*(6), 893-901.

Oliveira, P. C., Oliveira, C. G., Neri de Souza, F., & Costa, N. (2006). Teaching Strategies to Promote Active Learning in Higher Education. *Current Developments in Technology-Assisted Education*, 636-640. Retrieved February 25, 2007, from http://www.formatex.org/micte2006/pdf/636-640.pdf

Pallant, J. (2001). *SPSS Survival Manual* Open University Press.

Phillips, R. A., McNaught, C., & Kennedy, G. (2010, 28 June–2 July). *Towards a generalised conceptual framework for learning: the Learning Environment, Learning Processes and Learning Outcomes (LEPO) framework.* Paper presented at the 22nd annual World Conference on Educational Multimedia, Hypermedia & Telecommunications, Toronto, Canada.

Pillay, T., & Wallis, M. (2009). Enrolment Planning and its Implementation: The Durban University of Technology Experience. Durban: Durban University of Technology.

Plant, E. A., Ericsson, K. A., Hill, L., & Asberg, K. (2005). Why study time does not predict grade point average across college students: Implications of deliberate practice for academic performance. *Contemporary Educational Psychology, 30*(2005), 96-116.

Postman, N., & Weingartner, C. (1971). *Teaching as a Subversive Activity.* Great Britain: Penguin.

Punch, K. F. (2005). *Introduction to Social Research Quantitative and Qualitative Approaches.* London: Sage publications.

Race, P. (1999). *2000 Tips for Lecturers.* London: Kogan Page.

Ramsden, P. (1992). *Learning to Teach in Higher Education.* London: Routledge.

Ramsden, P. (2003). *Learning to Teach in Higher Education.* (2nd ed.). London: RoutledgeFalmer.

Recktenwald, G., & Edwards, R. (2010). *Guided Inquiry Laboratory Exercises Designed to Develop Qualitative Reasoning Skills in Undergraduate Engineering Students*. Paper presented at the fie. Retrieved 2011/01/17, from http://fie-conference.org/fie2010/papers/1547.pdf.

Ross, K. (2008, Thursday November 13 2008). MXit is a 'bad corporate citizen'. *Daily News,* p. 8.

Rothermel, K. J., Cook, C. R., Burnett, M. M., Schonfeld, J., Green, T. R. G. & Rothermel, G. (2000). Paper presented at the Proceedings of the 22nd international conference on Software engineering, *WYSIWYT Testing in the Spreadsheet Paradigm: An Empirical Evaluation.*(p. 230-239). Limerick, Ireland. Retrieved June 12, 2007, from http://delivery.acm.org/10.1145/340000/337206/p230-rothermel.pdf?key1=337206&key2=0672861811&coll=portal&dl=ACM&CFID=702 89561&CFTOKEN=15369411

Rowntree, D. (1987). Assessing Students: how shall we know them? London: Kogan Page.

Rule, P. (2007). Workshop Presentation on Oral Data Presentation. University of Kwa-Zulu Natal (UKZN).

Schumack, M. (2004). Use of a Spreadsheet Package to Demonstrate Fundamentals of Computational Fluids Dynamics and Heat Transfer. *The International Journal of Engineering Education*, *20*(6), 974-983.

Scott, T. C., & O'Connell, J. P. (1999). *Experiments to Accompany a First Engineering Thermodynamics Course*. Paper presented at the ASEE Annual Meeting. Retrieved 2010/12/21, from http://www.engr.uky.edu/~aseeched/papers/1999/scoco01.pdf.

Scott, T. C., & O'Connell, J. P. (2000). *Workshop Exercises for Connecting Fundamentals to Equipment in the First Thermodynamics Course*. Paper presented at the ASSE Annual Meeting. Retrieved 2011/01/17, from http://www.succeednow.org/papers/00/00708.pdf.

SouthAfrica.info reporter. (2007). South Africa's population. Retrieved August 15, 2010, from http://www.southafrica.info/about/people/population.htm

South African Qualifications Authority Act (No. 1521, Act 58 of 1995). Retrieved September 5, 2003, from unknown.

South African Qualifications Authority. (2000a). *The National Qualifications Framework and the Standards Setting*. Retrieved June 6, 2004, from **http://www.saqa.org.za**

South African Qualifications Authority. (2000b). *The National Qualifications Framework and Curriculum Development.* Retrieved June 5, 2004, from http://www.saqa.org.za

South African Qualifications Authority. (2001). *Criteria and Guidelines for Assessment of NQF Registered Unit standards and Qualifications*. Retrieved July 28, 2004, from SAQA.org.za/docs/critguide/assessment/assessment.pdf

South African Qualifications Authority. (2009). *National Diploma:Engineering:Mechanical.* Retrieved June 8, 2010, from http://allqs.saqa.org.za/showQualification.php?id=72230

Speich, J. E., Mclesley Jr., J. T., Richardson, J. S., & Gad-El-Hak, M. (2004). The Experiential Engineering Library. *The International Journal of Engineering Education, 20*(6), 1022-1033.

Sprackling, M. (1993). *Heat and Thermodynamics.* Basingstoke, Hants: McMillan.

Stringer, E. T. (1999). *Action Research* (2nd ed.). Thousand Oaks: Sage Publications, Inc.

Tan, O. S., Parsons, R. D., Hinson, S. L., & Sardo-Brown, D. (2003). *Educational Psychology A Practitioner-Researcher Approach An Asian Edition.* Singapore: Seng Lee Press.

Thurbon, G. A. (2006a). *Thermodynamics II (THRM201) Syllabus Details.* Unpublished HANDOUT. DUT (formerly DIT).

Thurbon, G. A. (2006b). *Thermodynamics II Learner Guide.* Unpublished HANDOUT. DUT (formerly DIT).

Ucak, N. O. (2007). PERSPECTIVE ON...· Internet Use Habits of Students of the Department of Information Management, Hacettepe University, Ankara. *The Journal of Academic Librarianship, 33*(6), 697-707.

Walpole, R. E., & Myers, R. H. (1978). *Probability and Statistics for Engineers and Scientists* (2nd ed.). New York: Collier Macmillan Canada, Ltd.

Yin, R. K. (2009). *Case Study Research Design and Methods* (4th ed.). Thousand Oaks: Sage Publications, Inc.

Young, M. (2001). Educational Reform in South Africa (1990-2000): An International Perspective. In A. Kraak & M. Young (Eds.) *Education in Retrospect: Policy and Implementation since 1990.* Pretoria: HSRC.

Zawilska, E. (2009). Programme Review and Evaluation Report. Durban: DUT.

LIST OF APPENDICES

Appendix A: Computer Group Assignment Codes

For assignment 1:

GROUP #	CODE
1	SDHH54
2	XFHJ78
3	GFYH89
4	DHGJ56
5	XDFG43
6	FG34NFG
7	UL76KUH
8	QW21RQW
9	YU98KYU
10	SD35CVX
11	ZM67U
12	UT45L
13	HU87X
14	BV23F
15	GF24N
16	84SJDV
17	26VNFG
18	91NGNF
19	73NHGF
20	24FDGN
21	SGFHN45
22	ASEGA68
23	HGULH56
24	VBNVM34
25	ZSCZV32
26	NJRGD22
27	SDFSG55
28	TERGJ27
29	HNJDR43
30	YJRDK87
31	XDV65H
32	THG54K
33	ASD33H
34	RTH99F
35	ERY44M
36	C25VBG
37	D65TRH
38	S89RTH
39	D76TYJ
40	S28ERK
41	TY98VFI
42	TD66YJI
43	HB45GUI
44	ST23RAI

For assignment 2:

GROUP #	CODE
1	GHULH67
2	BVNVM45
3	SZCZV43
4	JNRGD33
5	DSFSG66
6	ETRGJ38
7	NHJDR54
8	JYRDK98
9	DXV76H
10	HTG65K
11	SAD44H
12	TRH00F
13	REY55M
14	3C6VBG
15	7D6TRH
16	9S0RTH
17	8D7TYJ
18	3S9ERK
19	YT09VFI
20	DT77YJI
21	BH56GUI
22	TS34RAI
23	YT55JKI
24	DSHH65
25	FXHJ89
26	FGYH90
27	HDGJ67
28	DXFG54
29	GF45NFG
30	LU87KUH
31	WQ32RQW
32	UY09KYU
33	DS46CVX
34	MZ78U
35	TU56L
36	UH98X
37	VB34F
38	FG35N
39	59SJDV
40	73VNFG
41	20NGNF
42	48NHGF
43	53FDGN
44	GSFHN56

COMPUTER SPREADSHEET EXERCISE 1

Design a spreadsheet to generate a solution (including a graphic (PV diagram)), for a series of any three of the five processes (at any one time) dealt with in this course, that form a closed cycle.

It must:

- be your own (groups) work, with a signed declaration as such. You will need to save your allocated code into the spreadsheet as well as the file name.
- be capable of solving any combination of three processes, **at any one time**, that together form a cycle.
- be able to specify the work done for each process as well as the net work done for the cycle (including the direction).
- be user friendly (i.e. be able to be easily used by others).
- convey correct answers.

To perform this function, you will:

- be randomly divided into groups of 2 to 3 learners maximum.
- need to design its logic and layout before arriving at the computer laboratory as you will not have time to design it there, from scratch. It will be saved under your group's allocated code (also placed in a cell in your spreadsheet (to be used by the assessor group later)). You may only work on it in the computer laboratory. If you lock your file for security you will have to unlock it before it is assessed (otherwise you will get zero for the assessment) **(10% penalty for unlocking your file).**
- provide yourself with at least one correct example to test your method and solution of your designed spreadsheet (to be handed in when the design session is complete, with your group's code added).

You will be marked on (see assessment rubric for details):

- completeness (task, schedule, etc.).
- correctness (terms, symbols, answers, etc.).
- originality (of spreadsheet, sample problems, layouts, design of solution logic, etc.).
- ease of use by other users (who will later use it to solve a problem as assessors).

How will you be tested?

Once designed and saved it will be opened by another team (picked at random) and used to solve at least one type of problem (handed out at the reviewing session for use by the marking team) involving **any three** of the five processes.

The team marking it will (using the problem issued at the assessment session):

- use the spreadsheet assessed to assist in solving a problem.
- evaluate the spreadsheet (using the rubric provided).
- save the spreadsheet as a new file (using their marking code as a name) with their new solution stored in it.
- hand in the answers, obtained from the spreadsheet you are assessing.

A similar exercise for marking it will be completed randomly on 10% of the spreadsheets by the lecturer/marker and the mark allocations of his compared to the student evaluation marks. It is expected that you will take care reviewing the spreadsheet as the marks should be comparable.

To ensure anonymity only codes will be used as assigned to each group and also for the markers. Thus you won't know whose spreadsheet you are evaluating.

Copying will be dealt with in the normal manner, as defined in the DIT rule book (G13 (1), (o) and (p)).

Appendix C: Computer Assignment 2

COMPUTER SPREADSHEET EXERCISE 2

Design a spreadsheet to solve both the non-flow and steady flow energy problems, for **any variable** in either equation.

It must:

- be your own (group's) work, with a signed declaration as such. You will need to save your allocated code into the spreadsheet as well as the file name.
- be capable of solving both types of scenarios individually i.e. non-flow or steady-flow, **one at a time**.
- be able to specify the total and specific quantities of the associated properties.
- specify the energy flow direction(s).
- be use friendly (i.e. be able to be easily used by others).
- convey correct answers.

To perform this function, you will:

- be randomly divided into groups of 2 to 3 learners maximum.
- need to design its logic and layout arriving at the computer laboratory as you will not have time to design it there, from scratch. It will be saved under your group's allocated code (also placed in a cell in your spreadsheet (to be used by the assessor group later)). You may only work on it in the computer laboratory. If you lock your file for security you will have to unlock it before it is assessed (otherwise you will get zero for the assessment) **(10% penalty for unlocking your file).**
- provide yourself with at least one correct example to test your method and solution of your designed spreadsheet (to be handed in when the design session is complete, with your group's code added).

You will be marked on:

- completeness (task, schedule, etc.).
- correctness (terms, symbols, answers, etc.).
- originality (of spreadsheet, sample problems, layouts, design of solution logic, etc.).
- ease of use by other users (who will later use it to solve a problem as assessors).

How will you be tested?

Once designed and saved it will be opened by another team (picked at random) and used to **solve at least one type of each problem applicable** (NFEE and SFEE), handed out at the reviewing session for use by the marking team.

The team marking it will (using the problem issued at the assessment session):

- use the spreadsheet assessed to assist in solving a problem.
- evaluate the spreadsheet (using the rubric provided).

- save the spreadsheet as a new file (using their marking code as a name) with their new solution stored in it.
- hand in the answers, obtained from the spreadsheet you are assessing.

A similar exercise for marking it will be completed randomly on 10% of the spreadsheets by the lecturer/marker and the mark allocations of his compared to the student evaluation marks. It is expected that you will take care reviewing the spreadsheet as the marks should be comparable.

To ensure anonymity only codes will be used as assigned to each group and also for the markers. Thus you won't know whose spreadsheet you are evaluating.

Copying will be dealt with in the normal manner as defined in the DIT rule book (G13 (1), (o) and (p)).

Appendix D: Concept Test Page 1

	A	B	C	D	E	F	G	H	I	J	K
1											
2			Please put your student number here :		12345678						
3											
4		Please place a 1 (one) in the green area here, indicating the sign convention you use :									
5					W_{in}	W_{out}	Q_{in}	Q_{out}			
6			Library notes sign convention	1	-ve	+ve	+ve	-ve			
7			Eastop & McConkey sign convention		+ve	-ve	+ve	-ve			
8											
9											
10					PLACE A "1" (one) NEXT TO THE ANSWER IN THE GREEN AREA ONLY						
11					NOTE : you can choose more than one answer if necessay						
12					If you loose your position merely press the "home" key and scroll down						
13					to the next question to be answered						
14	Considering the PV diagram above :										
15	1) If the process a-b was adiabatic, which of the following statements is true :										
16			a) the work$_{a-b}$ is								
17			=0								
18			>0								
19			<0	1							
20			=PVlnr								
21			=(PaVa - PbVb)(n-1)								
22			=(PaVa -PbVb)/(γ-1)								
23			=(PbVb - PaVa)(n-1)								
24			=(PbVb -PaVa)/(γ-1)								
25											
26			b) the heat$_{a-b}$ is								
27			=0	1							
28			>0								
29			<0								
30			=PVlnr								
31			=(PaVa - PbVb)(n-1)								
32			=(PaVa -PbVb)/(γ-1)								
33			= - (PaVa - PbVb)(n-1)								
34			= - (PaVa - PbVb)/(γ-1)								
35											
36			c) the change in U$_{a-b}$ is								
37			=0								
38			>0								
39			<0								
40			=PVlnr								
41			=(PaVa - PbVb)(n-1)	1							
42			=(PaVa -PbVb)/(γ-1)								
43			= - (PaVa - PbVb)(n-1)								
44			= - (PaVa - PbVb)/(γ-1)								
45			=(PbVb - PaVa)(n-1)								
46			=(PbVb -PaVa)/(γ-1)								
47											
48			GO TO PAGE 2								

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Appendix D: Concept Test Page 2

	A	B	C	D	E	F	G	H	I	J	K
1											
2											
3											
4											
5											
6											
7											
8											
9											
10						PLACE A "1" (one) NEXT TO THE ANSWER IN THE GREEN AREA ONLY					
11						NOTE : you can choose more than one answer if necessay					
12						If you loose your position merely press the "home" key and scroll down					
13						to the next question to be answered					
14	Considering the PV diagram above :										
15	2) For the cycle a-b-c-a, which of the following statements is true :										
16		a) the net work is :									
17			=0								
18			>0	1							
19			<0								
20			=PVlnr								
21			=(PaVa - PbVb)/(n-1)								
22			=(PaVa -PbVb)/(γ-1)								
23			=(PbVb - PaVa)/(n-1)								
24			=(PbVb -PaVa)/(γ-1)								
25											
26		b) the net heat is :									
27			=0								
28			>0								
29			<0	1							
30			=PVlnr								
31			=(PaVa - PbVb)/(n-1)								
32			=(PaVa -PbVb)/(γ-1)								
33			=(PbVb - PaVa)/(n-1)								
34			=(PbVb -PaVa)/(γ-1)								
35											
36		c) the change in U is									
37			=0	1							
38			>0								
39			<0								
40			=PVlnr								
41			=(PaVa - PbVb)/(n-1)								
42			=(PaVa -PbVb)/(γ-1)								
43			=(PbVb - PaVa)/(n-1)								
44			=(PbVb -PaVa)/(γ-1)								
45											
46			GO TO PAGE 3								
47											

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Appendix D: Concept Test Page 3

PLACE A "1" (one) NEXT TO THE ANSWER IN THE GREEN AREA ONLY
NOTE : you can choose more than one answer if necessay
If you loose your position merely press the "home" key and scroll down
to the next question to be answered

Considering the diagram above :

1) This is a

a) open system
b) control volume system
c) closed system — 1
d) positive displacement system
e) a and b
f) b and c

2) The equation used to analyse this system is the

a) continuity equation
b) non-flow energy equation — 1
c) steady-flow energy equation
d) first law of thermodynamics
e) Bernoulli's equation
f) none of the above

Identify the following parts of the diagram :

3) the piston

a) 1
b) 2
c) 3
d) 4
e) 5 — 1
f) 6

4) the system

a) 1
b) 2
c) 3 — 1
d) 4
e) 5
f) 6

5) the work, W

a) 1
b) 2
c) 3
d) 4
e) 5 — 1
f) 6

6) the surroundings

a) 1
b) 2
c) 3 — 1
d) 4
e) 5
f) 6

7) the system boundary

a) 1
b) 2
c) 3
d) 4 — 1
e) 5
f) 6

8) the heat transfer, Q

a) 1
b) 2 — 1
c) 3
d) 4
e) 5
f) 6

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Appendix D: Concept Test Page 4

Considering the diagram above :

15) This is a
a) open system — 1
b) control volume
c) closed system
d) positive displacement system
e) a and b
f) b and c

16) The equation used to analyze this system is the
a) continuity equation
b) non-flow energy equation
c) steady-flow energy equation — 1
d) first law of thermodynamics
e) Bernoulli's equation
f) all of the above

Identify the following parts of the diagram :

17) the datum
a) 1
b) 2 — 1
c) 3
d) 4
e) 5
f) 6
g) 7
h) 8

18) the system
a) 1
b) 2
c) 3 — 1
d) 4
e) 5
f) 6
g) 7
h) 8

19) the outlet
a) 1
b) 2
c) 3
d) 4
e) 5 — 1
f) 6
g) 7
h) 8

20) the surroundings
a) 1 — 1
b) 2
c) 3
d) 4
e) 5
f) 6
g) 7
h) 8

21) the system boundary
a) 1
b) 2
c) 3
d) 4 — 1
e) 5
f) 6
g) 7
h) 8

22) the work, W
a) 1
b) 2
c) 3
d) 4 — 1
e) 5
f) 6
g) 7
h) 8

23) the inlet
a) 1
b) 2
c) 3
d) 4
e) 5 — 1
f) 6
g) 7
h) 8

24) the heat transfer, Q
a) 1
b) 2
c) 3
d) 4
e) 5
f) 6
g) 7 — 1
h) 8

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Appendix D: Concept Test Page 5

	A	B	C	D	E	F	G	H	I	J
1	12345678	YOUR OVERALL TOTAL FINAL SCORE IS :								
2										
3						42%	using the Library Notes sign convention			
4										
5										
6										
7		CONSIDERING IT PER SUB-SECTION (PAGE) A BREAKDOWN IS :								
8							Page 1	40%		
9							Page 2	100%		
10							Page 3	38%		
11							Page 4	30%		
12										
13	PLEASE SAVE THE FILE NOW USING ONLY YOUR STUDENT NUMBER									
14	LEAVING THE SCORE YOU CURRENTLY HAVE FOR RECORD PURPOSES									
15										
16										
17										

« < > » >| \ Page 1 / Page 2 / Page 3 / Page 4 \ Page 5 / F / G / H / I / J / K / L / M / N / C | ◄ |

MARKING RUBRIC FOR COMPUTER EXERCISE 1

ASSESSOR GROUP CODE:..............   DATE OF ASSESSMENT:..................
CODE OF SPREADSHEET ASSESSING:..................

First find the file you are supposed to assess by looking for it in the folder stipulated for the course. You will have to get its name from the list provided for this exercise (see the assistants). Make sure it is the correct one or otherwise you will have to redo the exercise.

Open it and save it in the following manner: use the "File, Save As..." option and save it in the folder "Assessment1", with your group's code, with an added suffix ".ASS" (eg MYGROUPCODE**.ASS**).

Next, complete the following problem using the spreadsheet assigned to you (see the schedule before starting the exercise). If you need to find any information before utilising the spreadsheet, show all working in the space below the problem. Save the spreadsheet you are assessing with your allocated code as a new file (leaving the original file intact and unchanged), as instructed above.

PROBLEM # :

Show **all working here** (i.e. any information you needed to calculate to complete the problem):

PLACE ANSWER(S) (FROM SPREADSHEET) HERE:

Did you have to unlock the spreadsheet before using it?   **N**   **Y**

Did you have to modify the spreadsheet before using it (other than entering data)? **N**   **Y**

RATE THE SPREADSHEET USING THE RUBRIC BELOW:

1 - strongly disagree - no evidence of progress shown / haven't started
2 - disagree   - little evidence of progress shown / barely begun
3 - neutral   - some evidence of progress shown / partially done, but incorrect
4 - agree   - evidence of progress shown and recorded / done, but incomplete
5 - strongly agree   - clear evidence of progress shown and fully recorded & complete

CRITERIA:	VALID EVIDENCE (direct/indirect)	1	2	3	4	5
Definitions, terminology and symbols	correct thermodynamic terms used					
	correct thermodynamic symbols used					
	correct spelling, grammar and punctuation					
Equations, data, notation and units	correct thermodynamic equations used					
	correct thermodynamic data used					
	correct scientific notation and units					
Information use	data transforms correctly					
	calculations performed correctly and accurately					
Document coherent	graph done and updates correctly					
	layout logical					
	easy to use					

TOTAL:

PLACE A SKETCH OF THE GRAPH DISPLAYED BELOW HERE:

ASSESSOR'S COMMENTS:

Spreadsheets good points:

Areas where spreadsheet could improve:

(please sign the GROUP register during the session)
LEARNER'S COMMENTS (not to be used by assessors):

LEARNER'S SIGNATURE(S):....................................... DATE:...........................

MARKING RUBRIC FOR COMPUTER EXERCISE 2

ASSESSOR GROUP CODE:..............   DATE OF
                                            ASSESSMENT:...................
CODE OF SPREADSHEET ASSESSING:..................

First find the file you are supposed to assess by looking for it in the folder stipulated for the course. You will have to get its name from the list provided for this exercise (see the assistants). Make sure it is the correct one or otherwise you will have to redo the exercise.

Open it and save it in the following manner: use the "File, Save As..." option and save it in the folder "Assessment2", with your group's code, with an added suffix ".ASS" (eg MYGROUPCODE**.ASS**). Put your new filename here:..

Next, complete the following problem using the spreadsheet assigned to you (see the schedule before starting the exercise). If you need to find any information before utilising the spreadsheet, show all working in the space below the problem. Save the spreadsheet with your allocated number as a new file (leaving the original file intact), as instructed above.

PROBLEM'S # :

NFEE:

SFEE:

Show **all working here** (i.e. any information you needed to calculate to complete the problem):

PLACE ANSWER(S) (FROM SPREADSHEET) HERE:

NFEE:

SFEE:

Did you have to unlock the spreadsheet before using it?   **N   Y**

Did you have to modify the spreadsheet before using it (other than entering data)? **N   Y**

RATE THE SPREADSHEET USING THE RUBRIC BELOW:

1 - strongly disagree   - no evidence of progress shown / haven't started
2 - disagree   - little evidence of progress shown / barely begun
3 - neutral   - some evidence of progress shown / partially done, but incorrect
4 - agree   - evidence of progress shown and recorded / done, but incomplete
5 - strongly agree   - clear evidence of progress shown and fully recorded & complete

CRITERIA:	VALID EVIDENCE (direct/indirect)	1	2	3	4	5
Definitions, terminology and symbols	correct thermodynamic terms used					
	correct thermodynamic symbols used					
	correct spelling, grammar and punctuation					
Equations, data, notation and units	correct thermodynamic equations used					
	correct thermodynamic data used					
	correct scientific notation and units					
Information use	data transforms correctly					
	calculations performed correctly and accurately					
Document coherent	layout logical					
	easy to use					

TOTAL:

ASSESSOR'S COMMENTS:

Spreadsheets good points:

Areas where spreadsheet could improve:

(please sign the GROUP register during the session)
LEARNER'S COMMENTS (not to be used by assessors):

LEARNER'S SIGNATURE(S):..   DATE:...........................

Appendix G: Declaration Form

<u>Declaration Form</u>

Signing below declares participation in production of the computer assignment and that it is your **own work**. If group members have not participated equally in the work then they should declare their required allocation of marks. If you have not signed this below **before** handing this declaration in, you will receive zero marks.

Student Number	Student Name	**Equal sharing of marks** Signature	**Un-equal sharing of marks**, with declared shared amount in % Signature	% share

GROUP CODE: **RUBRIC NUMBER:**

STUDENT STUDY SURVEY FOR THERMODYNAMICS II

Where applicable, please circle your desired answer to the statement.

ᵧ   uncomfortable answering a question please leave it out.

STUDENT NUMBER: ....

PERSONAL INFORMATION:

Matric symbol: Physics   Maths   English   other language (specify)...............
Place symbol here

English language: 1ˢᵗ   or   2ⁿᵈ   language

Ethnic group: Black   White   Coloured   Indian   other (specify)...............

Parent/ guardian highest qualification:
Father: < grade 12   grade 12   > grade 12
Mother: < grade 12   grade 12   > grade 12

Are you repeating the course: yes   no

My personal objective for this course is: ....%

INFORMATION EXCHANGE:

Access to computer: home   work   other (specify)............

How much time do you spend accessing information electronically a week:
    no time   1 hour   2 hours   4 hours   other (specify)............

Do you own a cell phone: prepaid   contract   no   other (specify)............

Cell phone information exchange: chat MXit web surf information other (specify)......

LIBRARY USE:

Have you done a library orientation course: yes   no

Have you ever consulted a librarian: yes   no
If yes, which one: engineering   science   other (specify)...............

How often do you use the library:
    daily   weekly   monthly   never

What do you read in the library:
    books   articles   journals   newspapers   other(specify).......
Specify eg's of titles (if possible)

SUBJECT SPECIFICS:

Do you have a copy of the library notes: yes   no
Do you have your own text book: yes   no
If yes, please specify author: ....
If not, what do you use as a reference: ....

How much time do you spend per week on thermodynamics:
        Four hours   three hours   two hours   one hour   no time   other.........

What type of activity do you perform during this time:
        reading   writing   tutorial   research   other(specify) ......
% time spent on activity   ....%   ....%   ....%   ....%   ....%

PRACTICAL EXPERIENCE/EXPOSURE:

Have you worked since leaving school: yes   no

Have you been exposed to any type of engineering: yes   no
If yes, can you specify the type: mechanical   electrical   civil   other (specify).......

Have you been exposed to any thermodynamic equipment/situations: yes   no
If yes, in what area(s):   boilers   refrigeration/air conditioning   engines
                          compressors   other(specify)...............

STUDY TECHNIQUES:

My preferred learning style is (if you have one favourite, mark it, if more than one equally so,
mark them (You may rank them if you wish)):

visual	prefer learning by seeing things	
auditory	prefer learning by hearing things	
read/write	prefer learning by reading/writing things	
kinesthetic	prefer learning by doing/acting out things	

(Reference: from http://www.vark-learn.com [accessed 2006/03/28])

I have visited a www site to determine my learning style: yes   no

I work in a group: yes   no
How often: always   sometimes   seldom   never

I rewrite notes out fully at home after lectures: yes   no
How often: daily   weekly   monthly   before tests   never

I consult my learner guide: often   sometimes   before a test   seldom   never

I attend tutorials: regularly   sometimes   if required   before a test   never

I do tutorial questions: all   some   try them   if pushed   never

Before a test I:

     get an early night   push an all-nighter   party   start the tuts   catch up notes

OTHER: Please add any other information you wish below:

INTERVIEW SCHEDULE AND POSSIBLE QUESTIONS (with prompts)

Explain that the purpose of the research is to achieve a better fit for the course to students' needs.

Get the permission of the interviewee to video/tape the proceedings before starting.

Permission granted:	yes
	no
Then check if all cell phones are switched off:	yes
	no
Have you started the timer:	yes
	no

Your preferred non-deplume is: _____

The purpose of my research is to compare different styles of teaching and to get a better understanding of the difficulties students face in studying the subject Thermodynamics.

KEY QUESTIONS: PROMPTS:

(no more than about five/six related to study)   (allied to questions)

1) What are your expectations of this course?
level
academic character
work load

2) What do you think you are getting out of it?
personally
conceptually
career direction

3) What use do you think it is going to be to you?
research direction
job/career development
changed perception

4) What difficulties has it presented you with?
work load
organisation of time
unfamiliarity of material

5) How did you find the presentation methods?
computer interactive
self-study
lectures

6) See next page for other possible questions

Explain what I am going to do in the data analysis:
- informing course development
- variation of teaching method styles
- etc
- etc

Interview techniques:

    - moving on - "That's very interesting. Another thing I want to ask ----"

    - prompts (for interviewee) - "What about -- (see right hand column for key words)"

    - probes - "I'm not clear about ---; tell me ---"
        - "That's a point I hadn't thought about; tell me ---"

<u>Other possible questions:</u>

KEY QUESTIONS:

                      PROMPTS:

(no more than about five/six related to study)
      (allied to questions)

What do attribute to your success/failure in this course?	lecture techniques work load
What study technique(s) do you employ?	individual team rewrite class notes
What do your friends do to do well in thermodynamics?	
What do your friends who do not do well in thermodynamics, do wrong?	tutors more periods
What extra support do you feel would help you to succeed in thermodynamics?	more tuts better notes
Do you get past papers from the library?	
How do you check your answers?	easy difficult short long
How did you find the practicals?	

study techniques

Appendix J: Assignment 1's Peer and Staff Comments on Rubric Forms

RUBRIC REF #	PEER ASSESSORS COMMENTS	
	Good points	**Improve**
13	looks neat but do not work	Try follow the instruction - and make it work
12	They have done correct calculations but in different problems therefore the graph is not a closed cycle.	They supposed to do one problem to get completely cycle.
7	Correct thermodynamics data used, calculations performed correctly and accurately	CORRECT SPELLING, GRAMMAR AND PUNCTUATION
11	NO EFFORT AT ALL	This group can improve their work by attending the lab sessions because no work was done at all.
40	EASY TO USE; NEAT AND GOOD APPEARENCE	SPELLING
30	nice layout	TWO MISSING PROCESSES needs to be put in.
34	Good layout of graphs.	function formulas
5	The group made an attempt to get the right results.	Spread sheet can improve by joining graphs 1,2,3. Also should be more user friendly.
25	The technical part of the spreadsheet impressed us.	In showing us the equations and details
1	N/A	
14	Its easy to use, graphs correctly formatted.	There should use raw data so that the graph will have many points.
10	Symbols terminology used correctly ; grammar good. transforms Data correctly	Layout of graph ; graph does not correspond to data
4	simple, easy to use	Need more information and graphs
28		graph.
15	Yes.	Formulae should be included in the spreadsheet.
3	~ IT WAS EASY TO USE. ~	~ TO MUCH COLOUR. ~ DIDN'T COMPLETE ALL PROCESSES
2	The graphs are correct and the calculations were done correctly	Neatness and instructions
17	Good logic, calculations are accurate	Accommodate for more processes
38		
9	- Easy to understand - User friendly	- Spreadsheet could be made to look better - Formulas need to be used in order to do the calculations.
37	Easy to use; visually appealing	Layout is not good enough
31	- Good layout (colour co-ordinated) - clear and precise instructions -	- Data not clearly shown – Spaced out data -
33	- Graphs clearly displayed; - Few clear instructions	- Needs clear explanations; - correct formulae; - Spacing between sections
45	Hard to use; need to have a good understanding of thermo's before using this.	Need to have instructions
42	Neat layout, calculations were known	Lack of program understanding, yet has shown an attempt
19	easy to understand, layout is very clear	work is satisfactory
18	Information is given clearly	Spreadsheet not complete
8	THE LAYOUT AND FORMAT WAS WELL DESIGNED AND PRESENTED.	
6	Attractive and bright Merging of graph	Improper use of equations Bad setup of information
29	RESPONSIVE, GOOD LAYOUT, EASY TO USE	CLEARER INSTRUCTIONS
35	- everything is systematic; - colourful; - All graphs are working	- More user friendly - no work values are changing; - Abit clustered - To much unnecessary information
32		. should be user-friendly, include equations, theory, logical steps, definitions, terminology, symbols
36		
26	LAYOUT OF THE SPREADSHEET WAS OK TO USE.	LAYOUT COULD BE IMPROVED ON, INSTRUCTIONS ON HOW TO USE THE SPREADSHEET CAN HELP. FORMULAE'S MUST BE PUT IN PLACE, SO THAT VALUES TRANSFORM CORRECTLY.
24		

16	good in calculations	Improve in graphs, correct terms
41	- Neatly laid out; - Graph up-dates itself	- spreadsheet should work out values itself.
43	Neat, Good layout, Graph changes with change in values.	Work done calculations need to be added. A single graph
20	you just plug the new values and it does all solutions and updates graph automatical	organizing its layout more logical

Students rubric cross Reference #	STAFF ASSESSORS COMMENTS		Comments on graphs
	Good points	**Improve**	
11	- ability to solve all processes simultaneously - simple layout to interact with, but needs instructions	- correct circular reference - add instructions - add a graph - correct equations to get data from the correct cell - no units displayed - doesn't add up work to get net work	No graph drawn.
19	- has some instructions - each process labelled - units indicated in some places	- processes and equations mixed - check spelling and grammar - constant volume process missing - don't know where to input data - all processes using/referring to the same data - correct equations shown mathematically - correct thermodynamic terms	Four different processes shown on four separate graphs, hence not cyclic.
20	- no spelling mistakes - correct terms and symbols used - equations shown relate process - graph changes, but not correctly	- needs some instructions - correct symbols (e.g. Kpa should be kPa) - doesn't update correctly when change values - don't use scientific notation if not required - no cycle PV diagram shown - missing two processes	Separate graphs and processes drawn.
40	- instructions given - layout attempts to set up problem	- check spelling - mixed units (e.g. bar and Pa) - processes appear to merge (i.e. share same data)	Graph drawn but incorrect.
14	good instructions.	could be improved by arranging the screen interface and combining all the three processes in one graph.	Combined graph shows all processes starting from same point.
26	I guess the group understands that theory but fails to use the spreadsheet to develop answers. Lack of experience in computing.	spreadsheet would have been of use if formulas were used in cells instead of calculated manually. I guess scope of assignment was not fully understood.	Three separate graphs on one page, but not cyclic. Updated by manual data input.
29		spreadsheets need to be interactive and consolidated with respect to all the three processes integrated into one sheet not multiple.	Three separate graphs on three different pages, hence not cyclic.
31	nice interface, not so easy to use as not much info provided as to how to use it.	could improve by providing more information as to how to use it.	Combined graph plots three processes together, but appears to be error in one process.

36	nice layout.	improvement required in highlighting where the data needs to be entered, combining all the processes in single graph.	Combined graph shows all processes starting from same point.
37	nice layout and interface.	could improve or useful if all the processes were combined.	Three separate graphs on one page, but not cyclic.
39	NONE!	Needs better understanding of the scope that is required in order to do that needs a more detailed experience of use of spreadsheets.	Three separate graphs on three different pages with incorrect equations in some, hence not cyclic.

Appendix K: Assignment 2's Peer Comments on Rubric Forms

RUBRIC REF #	ASSESSORS COMMENTS	
	Good points	**Improve**
18	layout logic and data is correct	check that the formula given c?? before saving your work
37	- simple layout	- include units; - Calculate h-values
28		
16	correct thermodynamic symbols use - aid equations	data transforms correctly
60	The spread sheet is not a user friendly, you have to figure out by yourself as an assessor how to use it. Must also be explained in words.	
61		
62	Presentation neatly done ; User friendly, values generated without any faults	Calculations of other quantities
70	They have used correct Thermodynamics Equations and good layout logic	Their work is not that much easy to use and scientific notations.
71	correct thermodynamic items were used and it was easy to understand The theory behind. there for the data was correct '	More information is not found which make it to be difficult to assess this file. And more calculations were supposed to be use d for the Assessor to understand the Spread Sheet easily.
72	They used THE correct thermodynamic terms and symbols and the correct equations	The layout logical should improve and it must be easy to use and the correct scientific notation and units
39		
19		
20		
34		
17 and 24	Not Done!	
11	They have done so well but they didn't calculate anything	
38	CORRECT THERMODYNAMICC DATA USED	They should pick up the values instead of labels or variables
10		
21		
30		
15		
25	good layout	data transfer
7		No work found.
45		

14	none	none
33		
29	Neatly done.	
23	Neat,	Typing the formulas on the spreadsheet
6	Didn't have a spreadsheet to assess.	
27	NEAT, CORRECT TERMINOLOGY,	PUT IN THE FORMULAE (EG. SFEE...), CORRECT DATA

Appendix L: Learner Guide's Programme Exit Level Outcomes, Specific Outcomes and Assessment Criteria Tables

Exit Level Outcomes

Exit Level Outcomes	Assessment Methods	Assessment Instruments
1) Apply mechanical engineering principles to diagnose and solve engineering problems. 2) Demonstrate mechanical engineering knowledge and skills in one or more specialized areas. 3) Communicate effectively in a technological environment.	• questioning written/oral • product evaluation • observation	• examination/tests • multiple response questions • oral questions • practical exercises/ demonstrations

Specific Outcomes and Assessment Criteria

Specific Outcomes	Assessment Criteria	Range	Evidence Required
specific outcome 1.1 - apply the language of thermodynamics and use the terminology appropriately	▪ correct thermodynamic definitions ▪ internationally accepted terminology used ▪ internationally accepted symbols and abbreviations used	▪ UK English ▪ SI units	▪ clear definitions ▪ own words where appropriate ▪ correct spelling, grammar, punctuation ▪ international abbreviations ▪ universal terminology and symbology
specific outcome 1.2 - solve thermodynamic mechanical engineering problems	▪ apply the correct thermodynamic equation to the situation ▪ calculate data precisely ▪ apply appropriate scientific notation and units	▪ tolerance of <1% ▪ manual data retrieval ▪ SI units	▪ use given information correctly ▪ use found information correctly ▪ correct answers ▪ rounding off or significant figures ▪ scientific notation ▪ correct units
specific outcome 2.1 - demonstrate mechanical engineering knowledge and skills	▪ utilise mechanical engineering equipment to take readings correctly ▪ manipulate or transform information to another form ▪ sources of information relevant to the problem are correctly identified and gathered	▪ tolerance of <1% ▪ manual data retrieval ▪ SI units	▪ take readings correctly ▪ interpret tables/charts correctly ▪ transform data correctly ▪ perform calculations accurately ▪ draw graphs correctly

specific outcome 3.1 - produce documents in a technological environment	▪ the appropriate type of document is chosen ▪ the appropriate document format is used ▪ the text is coherently organised at both language and structural levels ▪ word processing menus are correctly chosen and used to produce documents ▪ appropriate wording and use of referencing formats is used	▪ UK English ▪ SI units	▪ document content appropriate ▪ document prepared correctly and timeously ▪ document layout is correct and neat ▪ correct use of available facilities ▪ teamwork ▪ use of own words ▪ consistent use of recognised referencing formats
specific outcome 3.2 - interpret technical data	▪ technical data and categories are understood ▪ information can be correctly transferred from one form to another ▪ conclusions can be drawn from technical data with some expert help		▪ correct use of data ▪ correct interpretation of results ▪ correct conclusions drawn
critical cross-field outcomes	▪ think creatively and critically ▪ develop mature teamwork skills ▪ organise your resources ▪ information is collected, analysed or organised ▪ communicate effectively in various forms ▪ use technology effectively ▪ reflect on work covered and learning ▪ be responsible citizens ▪ be socially aware of others		▪ work as a team to produce an end product and be able to verbalise about it ▪ gather information from various sources and choose appropriate data for presentation ▪ use available technology ▪ be socially aware of your environment and others ▪ reflect on your learning

Appendix M: Assessment Rubric 1 sample problems

PROBLEM # 1:

A mass of gas is contained in a cylinder sealed by a well-fitting, frictionless piston. The gas starts at an equilibrium condition of 150kPa and occupies 0,004m^3 of space. The gas then undergoes as isochoric process until it reaches 250kPa. It then undergoes an adiabatic process until the volume reaches 0,00576m^3, after which it returns to the initial point isobarically. What work is completed during the cycle.

PROBLEM # 2:

A mass of gas is contained in a cylinder sealed by a well-fitting, frictionless piston. The gas starts at an equilibrium condition of 150kPa and occupies 0,00576m^3 of space. The gas then undergoes as adiabatic process until it reaches 250kPa. It then undergoes an isochoric process until the pressure reached is 150kPa, after which it returns to the initial point isobarically. What work is completed during the cycle.

PROBLEM # 3:

A gas expands reversibly in a cylinder with a frictionless piston from 550kPa and 0,024m^3 to 370kPa according to the law $PV^{1,25}=c$. It is then compressed according to the law $PV=c$ to the initial volume and returned to the initial state isochorically. What is the net amount of work done in the cycle.

PROBLEM # 4:
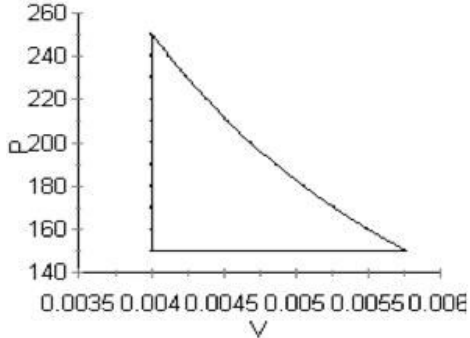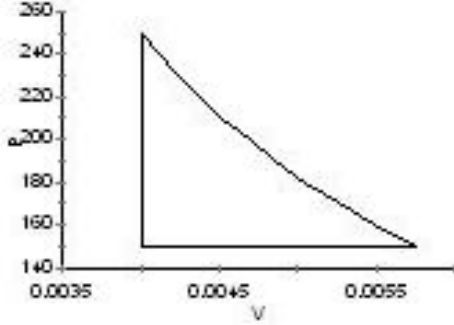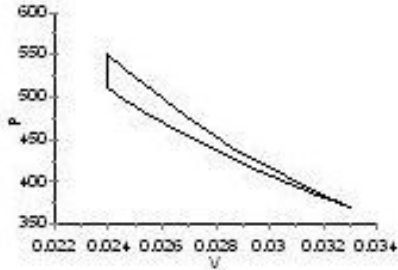
A gas expands reversibly in a cylinder with a frictionless piston from 510kPa and 0,024m^3 to 0,033m^3 according to the hyperbolic process. It is then compressed according to the law $PV^{1,25}=c$ to the initial volume and returned to the initial state isochorically. What is the net amount of work done in the cycle.

PROBLEM # 5:

A mass of gas is contained in a cylinder sealed by a well-fitting, frictionless piston. The gas starts at an equilibrium condition of 400kPa and occupies 0,055m^3 of space. The gas is cooled isobarically until it reaches 0,025m^3. It then undergoes an adiabatic expansion until the volume is again 0,055m^3, after which it returns to the initial point isochorically.

COMPUTER SPREADSHEET EXERCISE 1 - ASSESSMENT PROBLEM ANSWERS

QUESTION	ANSWER	PV DIAGRAM
1	W = +0,0760kJ/rev (output)	
2	W = -0,0760kJ/rev (input)	
3	W = +0,0717kJ/rev (output)	

4	W = -0,0621kJ/rev (input)	
5	W = -5,2875kJ/rev (input)	

Appendix O: Assessment Rubric 2 sample problems

PROBLEM'S # 1:

NFEE:

A frictionless piston is free to move within a cylinder and traps a quantity of nitrogen. If 600kJ of work is supplied to the nitrogen whilst the internal energy increases by 300kJ, determine the amount and direction of heat energy required to complete this process.

SFEE:

A thermodynamic device receives fluid at a steady flow rate of 5kg/min. The initial conditions are: pressure = 250kPa, velocity = 150m/s, internal energy = 600kJ/kg and specific volume = 0,03m^3/kg. At the exit of the device the fluid has conditions of: final pressure = 750kPa, velocity = 220m/s, internal energy = 500kJ/kg and specific volume = 0,3m^3/kg. If the fluid rises through 30m passing through the system, losing 80kJ/kg of heat along the way, determine the work done on or by the fluid during the process.

PROBLEM'S # 2:

NFEE:

A closed system, consisting of a frictionless piston moving within a cylinder, contains 2,5kg of gas. If 450kJ of heat is given off whilst 250kJ of work is supplied to the system, what is the change in specific internal energy of the air and is it an increase or decrease.

SFEE:

A system has initial conditions of 150kPa, 250m/s, internal energy of 300kJ/kg and specific volume = 0,04m^3/kg. At the exit of the device the fluid has conditions of 450kPa, 120m/s, internal energy 200kJ/kg and specific volume = 0,4m^3/kg. If the fluid drops through 23m passing through the system, gaining 95kJ/kg of heat along the way, determine the work done on or by the fluid during the process if the system receives fluid at a steady flow rate of 5kg/min.

PROBLEM'S # 3:

NFEE:

A frictionless piston is free to move within a cylinder and traps a quantity of oxygen. If 300kJ of work is extracted from the oxygen whilst the internal energy decreases by 150kJ, determine the amount and direction of heat energy required to complete this process.

SFEE:

A thermodynamic device receives fluid at a steady flow rate of 3kg/min. The initial conditions are: pressure = 250kPa, velocity = 150m/s, internal energy = 600kJ/kg and specific volume = 0.03m^3/kg. At the exit of the device the fluid has conditions of: final pressure = 750kPa, velocity = 220m/s, internal energy = 500kJ/kg and specific volume = 0.3m^3/kg. If the fluid rises through 30m passing through the system, using 210,74kJ/kg of work energy, determine the total heat to be added or removed to the fluid during the process.

PROBLEM'S # 4:

NFEE:

A closed system, consisting of a frictionless piston moving within a cylinder, contains 0,5kg of gas. If 350kJ of heat is added whilst 150kJ of work is extracted from the system, what is the change in specific internal energy of the air and is it an increase or decrease.

SFEE:

A system has initial conditions of 150kPa, internal energy of 300kJ/kg and specific volume = 0,04m^3/kg. At the exit of the device the fluid has conditions of 450kPa, 120m/s, internal energy 200kJ/kg and specific volume = 0,4m^3/kg. If the fluid drops through 23m passing through the system, gaining 95kJ/kg of heat along the way, generating 45,28kJ/kg of work by the fluid during the process, what initial velocity is required of the system if it receives fluid at a steady flow rate of 5kg/min.

PROBLEM'S # 5:

NFEE:

A frictionless piston is free to move within a cylinder and traps a quantity of gas. If 400kJ of heat is removed from the gas whilst the internal energy increases by 350kJ, determine the amount and direction of work energy required to complete this process.

SFEE:

A thermodynamic device receives fluid at a steady flow rate of 3kg/min. The initial conditions are: pressure = 250kPa, velocity = 150m/s, internal energy = 600kJ/kg and specific volume = 0.03m^3/kg. At the exit of the device the fluid has conditions of: final pressure = 750kPa, internal energy = 500kJ/kg and specific volume = 0.3m^3/kg. If the fluid rises through 30m passing through the system, using 210,74kJ/kg of work energy and 80kJ/kg of heat energy is removed from the fluid during the process, what is the final velocity at exit from the system.

COMPUTER SPREADSHEET EXERCISE 2 - ASSESSMENT PROBLEM ANSWERS

QUESTION	ANSWER- NFEE	ANSWER- SFEE
1	Q = -300kJ (output)	W = -17,56kW (on the system)
2	ΔU = -80kJ/kg (a decrease)	W = +3,77kW (out)
3	Q = 150kJ (input)	Q = -4,00kW (removed)
4	ΔU = 400kJ/kg (an increase)	c_1 = 250,0m/s
5	W = -750kJ (input)	c_2 = 220,0m/s

Appendix Q: Comparison of rubrics graphical solution sketch to Assignment 1 solutions

Rubric sketch compared to PROBLEM#4
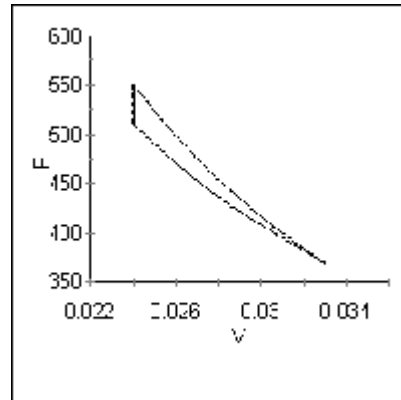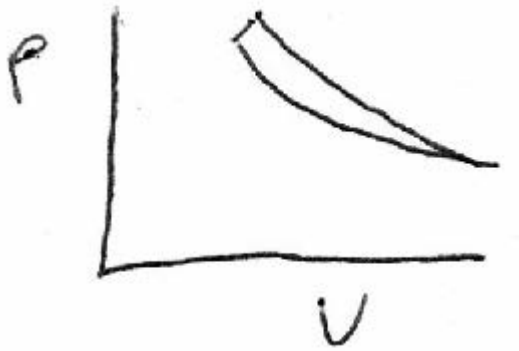
Rubric sketch compared to PROBLEM#2
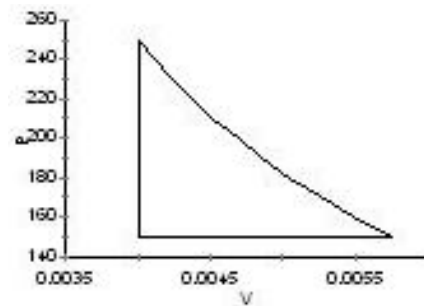
Appendix R: Summary of Interview Themes

Difficulties with Thermodynamics - this theme highlighted various difficulties that students mentioned during the interviews

Extra Support - this theme was used where students discussed extra support or other areas where they would have liked to have seen extra support

Learning Styles - this theme picked out aspects of students preferred learning styles

Learning Theories - this theme attempted to highlight learning theories as mentioned in Chapter 2

Study Techniques - this theme considered the various styles of study techniques students used

Success or failure - this theme was an attempt to highlight conversation where students appeared to consider their success(es) or failure(s) in the subject as a whole

Why do Thermodynamics - this theme picked up on where students saw the relevance of doing Thermodynamics as a whole

Appendix S: Keywords within each theme and their explanation of use

<u>**Keyword Summary Report**</u>

Difficulties with Thermodynamics

apply theoretical knowledge
>The ability to apply the theoretical knowledge that is discussed in lectures to their tutorial problems, practicals or other learning exercises.

attendance
>Refers to the problem of not attending a certain event, whatever it may be (lectures. tutorials, practicals, etc.).

attention
>Referring to the ability to hold onto information that is being passed on during lectures (i.e. keeping the audiences attention).

battle to study
>Used in reference to applying knowledge learnt to tutorial problems, possibly working in groups.

books
>Various meanings attached to this such as: use of books from the library such as limited copies implying ease of access, easy to understand or not. Also which books they have and if able to understand them.

calculations
>Refers to the mathematical calculations required to solve tutorial problems, test problems, etc.

cancelled lectures
>Used in relation to lectures being cancelled when too many students are absent due to other commitments, such as tests, etc. Not unique to Thermodynamics.

chemistry
>Thought that Thermodynamics was a chemistry type course, so very different from what the student first imagined the course was all about. Realised later that only a part of it was orientated in that direction as went through the course.

class baffled
>The class was generally confused as to what to do, how to get going with the computer tasks. Also used it in reference to class not knowing deeper meaning of Thermodynamics.

computer skills
>Relating to the ability of students to be able to utilise a computer to do things, having already done Computer Skills 1. Mentioned here by students as problematic. Also used in Excel, Thermodynamics formulas and using pc's.

concepts
>In relation to the concepts around which Thermodynamics is developed and their ability to understand and utilise them in problem solving.

Confusing
>Relating to being confused by the alternative teaching/learning approach, using spreadsheets.

difficult course
>Relating to the rumour about Thermodynamics being a difficult course. It gets

mentioned regularly and has been going on for generations of students.

easier

Thought the course was going to be easier, like basic chemistry and periodic tables, etc.

engineering background

Understand what a mechanical engineer does (before entering the Department).

English language

Used in connection with the "slow learners" being confused by the English language and terms used.

exams

The main examination, confusion with it and report writing. Also misleading as to what covered in the syllabus and what appears in the exam, from a time spent on a section perspective. Also saying more calculations in the exam compared to tests.

financial

Financial limitation posed impinging on ability to attend all classes, mainly transport here.

formulas

Confusion about the formulas used in thermodynamics. Their length, complexity, use in the spreadsheets, etc.

graphs

The ability to do some basic graph theory. Confused at school so left it and now becomes an even worse problem.

internet use

Limited access to the internet to be able to complete projects, assignments, practicals associated with any course. Have to resort to paying for outside services (off campus) to complete things on time.

kill fires

Used in relation to continuously learning new stuff and not being able to follow up on current stuff sufficiently, hence always "killing fires".

Lecturer's boring

Relates to the style of presentation used by the Lecturer. If they don't understand something students tend to switch off, thus finding things boring. This then leaves the students further behind in subsequent lectures exacerbating the situation.

lecturing style

Referring to the Lecturers preferred learning style. Also used in the context of the course presentation.

library book availability

Limited availability of books in the library and have to share across levels as well.

more direction

Direction in terms of guidelines to go about the computer task.

more in depth

Used in two contexts, one in relation to the subject going deeper than a previous Physics course done, and the other in relation to the deeper meaning required in this course.

more theory

Want to receive more theory on topics during the learning process.

more time

Used in several contexts. Time spent getting to understand the subject, concern about having enough time to complete their revision study, and in connection with class

theory time spent on other issues (e.g. computer spreadsheets and other issues).

notes

Referring to the library notes. Several different references occurred: equations have a different format to the text books, limited access to the library and notes, how easy to use, only using them for the first time when repeating the course, etc.

past paper answers

Don't have an answer to check with or work to for past exam papers.

prac venue size

Size of prac venue(s) not big enough to accommodate all students at the same time to synchronise class theory and practicals.

reports

Referring generally to the practical reports - writing them up, etc.

require rubrics

Require the use of a rubric as a guideline to perform various tasks.

rumours

Rumours spread by previous semester students about difficulties associated with Thermodynamics. Ongoing.

same colour lecturer

Referring to the ability to talk to a Lecturer of the same colour. It is easier.

slow learners

Made with reference to the ability of students to understand the English language.

synchronise

Run the class theory lectures and the practicals in synchronisation with each other to cover them at the same time.

terminology

Referring here to the terminology specifically associated with Thermodynamics.

textbook information

Referring to the information, or lack thereof, related to the course in the recommended textbooks.

tough lecturer

A rumour amongst students.

transport

Difficulties getting to campus. probable cause is financial.

tutorials

Used in several contexts, the doing of the tutorials, the comparison between them and the exams, the need to do them, obtaining worked out solutions from friends, etc.

workload

Comparing the workload of Thermodynamics in relation to other courses.

Extra Support

bigger prac venues

> To accommodate more students at a time so that the class lecture and laboratory practicals can be synchronised to cover the same work at the same time. This aids in the understanding as students can hear, see and do things together.

computer exercises

> Used in reference to the computer exercises which helped to support the theory by being able to apply the tuts practically on the computer to see the processes operating.

hand in questions

> Hand in random tutorial questions for marks. It will make students more likely to complete their tutorials and also work consistently and regularly, keeping up to date.

improved computer facilities

> Lack of availability of computer facilities put students at risk of failure. More computers and longer open access times are required.

introductory overview

> Give a broad overview of the whole syllabus as an introduction. Then go back over each section in more detail afterwards.

lecturer same colour

> Students would prefer to talk to lecturers of the same colour.

make S2 one year

> A rumour exists of making S1 a full year and keeping the rest (S2 to S4)the same. Suggestion is to keep S1 the same and expand S2 to a year as that appears to be the bottleneck.

make theory practical

> Try to make the theory discussed in class more practically orientated.

mark tuts yourself

> Use peer group marking to mark the students tutorial question answers.

more direction

> Clear directions on how to go about doing the computer spreadsheets.

more notes

> Referring to the notes available to students in the Library on Campus.

more tut periods

> Put more tutorial periods in the syllabus.

more tuts

> Put more tutorials in the syllabus.

solve tut problems

> Students don't attend the tutorial periods because they haven't even done the tutorials themselves first.

Study groups

> Students forming into study groups would benefit themselves and others.

test per section

> Rather have a test after each section than have only two major tests covering several sections.

tut solutions

> Have same solutions worked out for the tutorial problems that students can refer to. Could be in any format in any place.

Tutors

> The question of tutors as an aid to assist students in various aspects of the course was

discussed. Some were for it and others though it would be a waste of time.

Learning Styles

apply it
> Used in connection with the computer spreadsheets where you apply the knowledge. helping see things in a more practical way. Also in connection with the protocols. where you are having to apply yourself. to get you thinking about what you've just done.

auditory
> Prefer listening to things to learn.

complement
> Two different areas of learning are both required to help in the overall understanding of the subject e.g. theory and practicals complement each other.

consistent
> The need to be consistent in ones approach to teaming, a discipline thing.

copy
> A style of learning not popular in Tertiary institutions.

kinesthetic
> A style of learning whereby one learns by doing or acting out things.

parasite
> Learners who latch on to your work and use it and expect the same marks with little or no effort of input from themselves.

parrot
> Learn things parrot fashion.

read/write
> prefer to learn things by reading and/or writing things.

three prong solution approach
> Approach problem solving in a three phase manner _ first attempt it, then ask other students for help, then approach Lecturer for help.

visual
> Prefer to learn things via pictures/diagrams/graphs/etc. Also in reference to visualising an answer but not necessarily writing it out on paper.

Learning Theories

deep
> As defined by Marton and Saljo.

surface
> As defined by Marton and Saljo.

Study Techniques

assessing
> Used as a technique whereby one student group assessed another group's computer assignment using a predefined rubric sheet.

clear guidelines
> Used in reference to the computer spreadsheet exercises in that the guidelines were clearly defined on the handout before the assignment began, indicating what was required, limits, assessing, etc.

compare answers
> Students comparing the answers they get for tut problems. past paper problems, etc.

compare similar problems
> Looking at similar worded problems to try and use a known solution to help solve another unknown problem.

computer exercises
> Refers to the two computer spreadsheet assignments, done by the class in the first half of the semester, as an alternative teaching/learning style.

consult a Lecturer
> To seek assistance from a Lecturer, in any form, at any time during the semester, for any aspect of the course, be it tutorials, practicals, projects, etc.

consult other students
> To liaise with other fellow class members, in the absence of a lecturer (e.g. after hours), to assist one in any way.

explain
> Referred to asking a fellow student, who understands the course better, to explain that section to the student, rather than going to the Lecturer for assistance

find similarities
> Find similarities in tutorial questions and then making the assumption that if that type comes up again, the student would be able to handle similar type problems, but not sure if actually has the right answer.

format
> Referring to the "style" of exam and test papers.

individual
> Referring to studying alone as an individual rather than as a team or part of a study group.

key points
> Take down only the key points during a lecture.

last minute
> Leaving the studying and doing of tutorials, etc. to the last minute, thus not giving much time for reviewing the work.

notes summarised
> Summarised notes referring to the library notes being fairly brief and to the point, reducing the syllabus work load.

past papers
> Refers to the past papers of Thermodynamics available to students in the library.

prac report rubrics

    Guidelines, set out in tabular format, to help students in the writing of their practical reports, normally issued in practical sessions only.

prerequisite

    Theory a prerequisite for the practical (i.e. understand things in a logical sequence).

rely on students

    Students relying on each other to help each other along the way, rather than obtaining assistance from Lecturers or other staff members of the Institute.

rewrite notes

    To take what notes one wrote during a lecture and rewrite them at home in the evening, a study technique employed by some students.

see changes

    Specifically referred to the computer exercises where one could see the changes in the processes as parameters changed, either through the cell values changing or the graphical output.

self study

    Being responsible for your own learning and going out and doing it.

solve tut problems

    Mentioning the possible synchronisation of the class theory, tutorial problems and practicals such that all components are done at the same time to see a relationship between all three components of the course.

study group

    A group of students getting together to study in their own time.

study/learner guides

    A booklet issued to each student at the start of the course. giving details relating to the program, the course, the syllabus, assessments, rules and guidelines, etc.

teamwork

    The requirement for students to work together to achieve common goals, in whatever form that may be (e.g. practicals, projects, etc.).

textbook references

    Utilise any of the recommended textbooks (mentioned in the study/learner guide) as further reference material, for any aspect, at any time during the course, excluding the library notes in this instance.

use class notes

    Utilise the notes, for the entire syllabus, that are available for students to photostat in the library, as opposed to buying a text book.

use library

    To actually go into the library and get books, files, notes out of it themselves.

work consistently

    Work all the time rather than in fits and starts, so that the pace is more even. Also referred to their class mates doing this more than the interviewee themselves.

work daily

    Do at least something related to the Thermodynamics course every day, after hours.

Success or failure

application
> Mostly used in connection with application of the theory to practice. Also referred to applying oneself and another to a better grounding before applying the theory.

assist students
> Help other students when having problems if can do so, especially out of hours.

attendance
> Referring to attendance of lectures. tutorials and lack thereof.

blame the lecturer
> Blame the lecture for their failing, even right from the start, almost pre-empting a failure.

cheating
> Cheating in any form in any component of the syllabus.

commitment
> Commitment or lack thereof to hard work, knuckling down and doing it.

consistency
> Consistently working at solving problems and being consistent in ones approach.

curious
> Having a curiosity for the course and a willingness to explore further.

dedication
> Have a sense of dedication towards the course or work, to keep moving on.

demotivated
> Demotivated to carry on with the course as didn't understand what was going on. A new language and terminology, etc.

discipline
> Mostly referring to having the self-discipline to work consistently. Some reference to fellow students having better self-discipline than themselves.

focus on weak/strong points
> Student focussing on their own weak or strong points, or not, in trying to learn Thermodynamics.

hard work
> Thermodynamics is hard work. Have to put lots of hard work in. Some referral to fellow students putting more hard work in than themselves.

interesting
> Generating an interest for the course, sometimes too late.

key importance
> Mentioned the first part of the course having a key importance for the rest of the course. Understanding that part would help a lot in the later work.

language
> Need to understand the language of Thermodynamics, rather than language being a barrier to understanding (i.e. English language).

lazy
> Students themselves being lazy and not doing things for themselves.

method approaching problems
> A way of tackling problems, being methodical in the approach. Also working continuously at it.

negative attitude
> Negative attitude of students coming into the course, sometimes caused by hearing

what past students have to say about the course.

not work hard enough

Talking about themselves not working hard enough sometimes, but also mentioning their friends who fail, also not doing so.

panic

Referring to fellow students who haven't done enough work before a test and start to panic when realise they don't understand how to do things and realise that they have more to learn.

past papers

Referring mostly to getting them from the library for swotting purposes. Two questions were posed with that in mind - getting them out and then checking answers.

practical

Two different uses of the term. One referred to the computer exercise being a practical way of demonstrating the theory. The other talked about the practicals and difficulties writing up the reports as had to think about what they did and draw conclusions.

race

Used in the content of ethnicity. Easier to talk to someone of the same race.

read

Read one's text book, but started doing it too late to matter.

stress

Know that Thermodynamics and the Lecturer are hard, causing them stress.

too late

Started to get the hang of the subject, but it was too late to make a go of it.

tried

Try having a go at it for oneself initially. Need to seek help if can't do it, but often stop there, or go to the wrong person for assistance. Others keep trying until they succeed.

understanding

Used in relation to understanding the course, the terminology, students gaining an understanding and the practicals.

venue size

Suggested that the practical venue may be too small such that cannot run theory, tuts and practicals synchronously.

Why do Thermodynamics

career

See Thermodynamics as associated with their career paths (e.g. Eskom and GCC).

exciting

Suddenly found Thermodynamics to be exciting and wants to know and do more.

get a GCC

Realise it is a subject needed to write one's GCC.

get to next level

Need to pass it to get to the next level (i.e. Thermodynamics III, or just S3).

interest

An interest in the subject.

knowledge

Gain a knowledge of Thermodynamics. Also used to say that one needs to use one's

Thermodynamic knowledge in plant operation.

practical
> Mentioning that Thermodynamics has practical applications. Also seen its application in practice in plant operation.

real life
> Thermodynamics has real life applications. Seen it used in real life situations. Is needed for GCC.

relate to other subjects
> Sees a relationship between Thermodynamics and other subjects, such as fluids and mechanics and maybe design.

thinking as an engineer
> Thermodynamics gets you thinking as an Engineer. Also useful in a career choice that may be associated with it (e.g. Eskom).

tools for the job
> The necessary theoretical background covered for it be useful and applicable in plant.

understanding
> To gain a better understanding of Thermodynamics itself. Also need the understanding to go to the next level, S3.

Appendix T: One way ANOVA test 1 and test 2 results summary for previous semester marks

TEST 1 RESULTS FOR PREVIOUS SIX SEMESTERS

Oneway

Descriptives

Test 1 mark

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	110	39.88	17.151	1.635	36.64	43.12	6	91
2	117	38.00	15.888	1.469	35.09	40.91	8	82
3	103	40.96	19.186	1.890	37.21	44.71	0	100
4	104	34.73	14.306	1.403	31.95	37.51	8	74
5	96	52.30	19.332	1.973	48.39	56.22	12	92
6	110	40.55	16.345	1.558	37.46	43.64	7	94
Total	640	40.85	17.786	.703	39.47	42.23	0	100

ANOVA

Test 1 mark

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17549.836	5	3509.967	12.055	.000
Within Groups	184599.5	634	291.166		
Total	202149.3	639			

TEST 2 RESULTS FOR PREVIOUS SIX SEMESTERS

Oneway

Descriptives

Test 2 mark

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	110	57.20	18.656	1.779	53.67	60.73	12	94
2	114	48.80	24.905	2.333	44.18	53.42	6	100
3	101	44.23	27.647	2.751	38.77	49.69	2	100
4	97	52.46	24.635	2.501	47.50	57.43	2	100
5	87	38.25	20.724	2.222	33.84	42.67	0	96
6	108	55.84	24.822	2.388	51.11	60.58	4	100
Total	617	49.87	24.544	.988	47.93	51.81	0	100

ANOVA

Test 2 mark

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	25503.021	5	5100.604	9.018	.000
Within Groups	345580.6	611	565.598		
Total	371083.6	616			

Appendix U: Post Hoc Tukey tests outputs for tests 1 and 2 for previous semesters

Post Hoc Tests – Dependent variable Test 1 marks

Multiple Comparisons

Dependent Variable: Test 1 mark

	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Tukey HSD	1	2	1.879	2.266	.962	-4.60	8.36
		3	-1.082	2.340	.997	-7.77	5.61
		4	5.148	2.334	.236	-1.52	11.82
		5	-12.423*	2.383	.000	-19.24	-5.61
		6	-.673	2.301	1.000	-7.25	5.90
	2	1	-1.879	2.266	.962	-8.36	4.60
		3	-2.961	2.306	.794	-9.55	3.63
		4	3.269	2.300	.714	-3.30	9.84
		5	-14.302*	2.350	.000	-21.02	-7.59
		6	-2.552	2.266	.871	-9.03	3.93
	3	1	1.082	2.340	.997	-5.61	7.77
		2	2.961	2.306	.794	-3.63	9.55
		4	6.230	2.372	.092	-.55	13.01
		5	-11.341*	2.421	.000	-18.26	-4.42
		6	.410	2.340	1.000	-6.28	7.10
	4	1	-5.148	2.334	.236	-11.82	1.52
		2	-3.269	2.300	.714	-9.84	3.30
		3	-6.230	2.372	.092	-13.01	.55
		5	-17.571*	2.415	.000	-24.47	-10.67
		6	-5.821	2.334	.127	-12.49	.85
	5	1	12.423*	2.383	.000	5.61	19.24
		2	14.302*	2.350	.000	7.59	21.02
		3	11.341*	2.421	.000	4.42	18.26
		4	17.571*	2.415	.000	10.67	24.47
		6	11.751*	2.383	.000	4.94	18.56
	6	1	.673	2.301	1.000	-5.90	7.25
		2	2.552	2.266	.871	-3.93	9.03
		3	-.410	2.340	1.000	-7.10	6.28
		4	5.821	2.334	.127	-.85	12.49
		5	-11.751*	2.383	.000	-18.56	-4.94

*. The mean difference is significant at the .05 level.

Post Hoc Tests – Dependent variable Test 2 marks

Multiple Comparisons

Dependent Variable: Test 2 mark

	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Tukey HSD	1	2	8.402	3.179	.089	-.69	17.49
		3	12.972*	3.277	.001	3.60	22.34
		4	4.736	3.313	.709	-4.73	14.21
		5	18.947*	3.412	.000	9.19	28.70
		6	1.357	3.222	.998	-7.85	10.57
	2	1	-8.402	3.179	.089	-17.49	.69
		3	4.571	3.250	.723	-4.72	13.86
		4	-3.666	3.285	.875	-13.06	5.73
		5	10.545*	3.386	.024	.87	20.22
		6	-7.044	3.193	.236	-16.17	2.09
	3	1	-12.972*	3.277	.001	-22.34	-3.60
		2	-4.571	3.250	.723	-13.86	4.72
		4	-8.236	3.381	.146	-17.90	1.43
		5	5.975	3.479	.521	-3.97	15.92
		6	-11.615*	3.292	.006	-21.03	-2.20
	4	1	-4.736	3.313	.709	-14.21	4.73
		2	3.666	3.285	.875	-5.73	13.06
		3	8.236	3.381	.146	-1.43	17.90
		5	14.211*	3.512	.001	4.17	24.25
		6	-3.379	3.327	.913	-12.89	6.13
	5	1	-18.947*	3.412	.000	-28.70	-9.19
		2	-10.545*	3.386	.024	-20.22	-.87
		3	-5.975	3.479	.521	-15.92	3.97
		4	-14.211*	3.512	.001	-24.25	-4.17
		6	-17.590*	3.426	.000	-27.38	-7.80
	6	1	-1.357	3.222	.998	-10.57	7.85
		2	7.044	3.193	.236	-2.09	16.17
		3	11.615*	3.292	.006	2.20	21.03
		4	3.379	3.327	.913	-6.13	12.89
		5	17.590*	3.426	.000	7.80	27.38

*. The mean difference is significant at the .05 level.

Appendix V: Summary of DUT student academic disciplinary cases between 2003 and 2009

Source : Office of the Registrar (responsible for prosecuting student academic cases)

	Number of cases in the Year (guilty in brackets)						
Offences / Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
crib notes	10 (10)	13 (11)	22 (21)	54 (50)	53 (52)	44 (43)	23 (20)
plagiarism(1)	1 (1)	1 (1)	15 (3)	22 (22)	24 (24)	42 (41)	5 (5)
communication	2 (2)				1 (1)		1 (1)
collusion	1 (1)		2 (2)				
cell phone			1 (1)		2 (2)		2 (2)
fraud (collusion)				2 (2)			
fraud (medical certificate)					1 (1)	1 (1)	
fraud					2 (2)	3 (3)	4 (4)
borrowed material				1 (1)			
assistance					4 (4)		3 (3)
stabbing					1 (1)		
pastry theft							1 (1)
TOTALS	**14 (14)**	**14 (12)**	**40 (27)**	**79 (75)**	**88 (87)**	**90 (88)**	**39 (36)**
not prosecuted	0	2	13	4	1	2	0

Notes : (1) From 2009 the DUT Plagiarism Policy (in DUT, 2010, p.21) came into force in which first offences are to be handled by the respective Departments and are therefore not included here.

Appendix W: Learning Outcomes for Thermodynamics II

THERMODYNAMICS II (THRM201) SYLLABUS DETAILS

Introduction - basic concept

define and use the terms - working substance, property, state, state point, phase, process, cycle, energy, work, power, efficiency
quantify properties in terms of both primary and derived units
differentiate between the practical and absolute temperature scales
identify and use various temperature measuring devices, including limitations
describe the term "specific" and apply it correctly
define the terms work and heat and apply the sign convention to their quantities in calculations
define the processes involved in thermodynamics
derive the equations for the different processes and apply them accordingly
calculate the energy quantities and flow directions, property changes, efficiencies, etc. associated the various processes
define the term specific heat capacity and use it in calorimetry and other associated areas
explain and use the term "water equivalent"
illustrate and apply the concept of the heat engine

Systems and Laws - basic rules

sketch, explain and use the systems employed to analyse situations
describe and use the non-flow and steady-flow energy equations in the appropriate applications
describe and use the laws of thermodynamics
define and use the continuity equation

Vapours - two phase systems

describe the differences between gases and vapours
explain a two phase system
describe the formation of steam and identify the terms sensible and latent heat
define the term saturation temperature and pressure and analyse their relationship
describe the triple point of water
find and use the specific heat capacity of liquid water and vapour and calculate enthalpies from them
define the term "degree of superheat" and find it
describe a wet vapour, define dryness fraction and calculate it from data (also wetness fraction)
sketch the T-h diagram, plot various processes on it and find the quantities of properties involved from tables and interpolate
define specific volume and calculate it for various phases using data from tables
define density and find its relationship to specific volume
sketch the P-v diagram, plot various processes on it and find the quantities of properties involved from tables and interpolate
find the internal energy from other properties
describe throttling of a vapour and calculate the quantities involved
sketch, label and describe the operation of dryness fraction calorimeters
determine the dryness fraction using a separating calorimeter, throttling calorimeter and combination of both
calculate the energy transfers associated with the various processes (including directions) using the laws of thermodynamics

Entropy - an important property and analysis tool

define the term entropy
calculate the change of entropy of vapours, from a liquid through to superheat
sketch the T-s diagram for vapours, plot various processes on it and find the quantities of properties involved from tables
sketch the h-s diagram (Mollier chart), plot various processes on it and find the quantities of properties
calculate the change of entropy of gases for various processes
sketch the T-s diagram for gases, plot various processes on it and find the quantities of properties involved

Combustion - the generation of heat

distinguish between exothermic and endothermic reactions
distinguish between elements, compounds and mixtures
find or calculate the relative atomic masses and molecular masses of substances involved in combustion
know and use the chemical symbols for substances involved in combustion
know the composition of air by mass and volume and use it accordingly in required calculations
identify the basic components and applications of various solid, liquid and gaseous fuels used in industry
write down and balance the stoichiometric equations of combustion for C, H_2 and S and other fuels by mass and volume
calculate the stoichiometric mass and volume of air required for complete or incomplete combustion of a fuel
calculate the products of combustion by mass and volume and convert one to the other (Avogadro's Hypothesis), expressing answers as
       percentages
define dry flue gases and calculate percentage products
draw, label and describe the Orsat apparatus and its use, and the Fyrite analyser and its use
calculate the excess air required and include it in products of combustion
define HCV and LCV and calculate them from the known composition of a fuel
draw, label and describe the Bomb calorimeter and its use

draw, label and describe the Gas calorimeter and its use

Steam Plant - the generation of steam

sketch, name and describe the basic function of the main components of a steam plant
distinguish between fire-tube and water-tube boilers and identify the main boiler components
analyse energy transfer in the various boiler components and calculate them
define boiler efficiency and calculate it
define equivalent evaporation from and at 100°C and calculate it
sketch, label and describe the surface and jet condensers and distinguish between them
sketch, label and describe the barometric leg and low level condenser and distinguish between them
perform basic energy balance calculations on condensers
plot the Carnot cycle on various two phase system charts, describe the processes involved and calculate the cycle efficiency
plot the Rankine cycle on various two phase system charts, describe the processes involved and calculate the cycle efficiency
describe basic water treatment requirements and effects

Gases - single phase systems

define and apply Boyle's Law
define and utilize Charles Law
describe and use Joule's Law
define and employ the characteristic equation of a perfect gas
define the specific heat capacities of a gas, namely c_p and c_v
define the characteristic gas constant (specific gas constant), R
define the universal gas constant, R_o
analyse the relationship between c_p, c_v, R and R_o
analyse and use the equations associated with various process changes for gases
draw the P-V diagrams for various process combinations or cycles
solve for the ideal gases properties at the state points for a cycle given any starting conditions
calculate the associated energy transfers (including directions) using the laws of thermodynamics

Appendix X: Letter given to Interviewees

Department of Mechanical Engineering

Steve Biko Campus

Durban University of Technology

P. O. Box 1334

Durban

4000

16th October 2006

Dear Mr. (student name)　　　(student number)

re : **THERMODYNAMICS II INTERVIEW INVITATION**

I am pleased to inform you that you have been invited to take part in the interviews previously mentioned in the introductory declaration letter, signed by yourself at the beginning of the semester.

Please could you see me as soon as possible to book a possible time for this interview of one hour maximum.

Should you be unable to participate for any reason please inform me soonest.

Thanking you in anticipation.

Yours faithfully,

....

G. A. THURBON

Senior Lecturer

Mechanical Engineering Department.

Appendix Y: Time spent on doing Thermodynamics per week

Time spent on doing Thermodynamics per week

Time spent doing Thermodynamics per week * Final mark as pass or fail Crosstabulatic

			Final mark as pass or fail		
			Pass	Fail	Total
Time spent doing Thermodynamics per week	3 to 4 hours	Count	14	8	22
		% within Time spent doing Thermodynamics per week	63.6%	36.4%	100.0%
	1 to 2 hours	Count	9	19	28
		% within Time spent doing Thermodynamics per week	32.1%	67.9%	100.0%
Total		Count	23	27	50
		% within Time spent doing Thermodynamics per week	46.0%	54.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.919[b]	1	.027		
Continuity Correction[a]	3.733	1	.053		
Likelihood Ratio	4.988	1	.026		
Fisher's Exact Test				.045	.026
Linear-by-Linear Association	4.821	1	.028		
N of Valid Cases	50				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.12.