THE LEARNING STYLES AND APPROACHES OF STUDENTS STUDYING THE FUNDAMENTAL ALGORITHMIC CONCEPTS COURSE AT THE UNIVERSITY OF THE WITWATERSRAND

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A research report submitted to the Faculty of Science, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Science.

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DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

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28th day of March 2005

ABSTRACT

Many students fail the Fundamental Algorithmic Concepts course, in first year Computer Science at the University of the Witwatersrand. To obtain an understanding of why this occurs, the learning styles and learning approaches of the students studying the course and the relationship of these concepts with student grades were researched. A predominately qualitative paradigm was used, supplemented with quantitative data. Two research designs were selected: a survey to get a broad overview of the sample and an ethnographic design to provide an in-depth description of a small group. Existing instruments were used for the survey, namely Felder and Soloman's Index of Learning Styles and a learning approach diagnostic test that was constructed in South Africa. An interview with open-ended questions was used for the ethnographic research. Contrary to expectations, the results of the study indicated that the adoption of a deep learning approach did not imply success. The findings suggest that a strategic learning approach may be required to achieve good grades. In contrast to other studies, over 65% of the sample population were black students. It was found that black students tend to adopt a deeper learning approach than the rest of the students. From a learning style perspective there was some new evidence to indicate that the more intuitive or global a student was, the deeper the approach the student adopted to learning. A large percentage (over 80%) of the population were visual learners and an unusually high percentage (over 60%) were reflective learners. The lecturer should match the workload and assessment methods with the desired learning approach of the students. The lecturer should also encourage the students to adopt a strategic learning approach where appropriate. In addition, the lecturer should pay particular attention to incorporating teaching styles that accommodate students with visual and active learning style preferences.

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1. INTRODUCTION TO THE PROBLEM AND AIMS OF THE STUDY

1.1 Introduction

There is a very high failure rate in the first year Computer Science course at the University of the Witwatersrand (Wits), South Africa. One of the lecturers wished to investigate some of the factors contributing to this. He would especially like to identify those factors over which he has possible influence. In particular the learning styles and approaches of students who are struggling with the Fundamental Algorithmic Concepts (FAC) course may be important. The research study was primarily exploratory in nature. Both a survey design to provide a broad overview, as well as an ethnographic design to provide an in-depth description, were followed. Both quantitative and qualitative methods such as questionnaires and interviews were used for data collection. Descriptive statistics were used to summarise the data and profiles of students studying the FAC course were developed.

This first chapter outlines the problem, the rationale for the study and the aim of the study with the specific research questions to be explored. A brief synopsis of the methodology followed is provided and the key results are highlighted. Finally an overview of the structure of the remainder of the research report is provided.

1.2 Statement of the Problem

At Wits many of the students fail the first-year Computer Science course. In particular, many students (54% in 2003) fail the FAC course. The FAC course covers proof techniques and introduces some of the well-known algorithms and data structures (Sanders, 2004). It is a difficult conceptual course, and based on anecdotal evidence the lecturer's impression was that many of the students memorise algorithms rather than study to obtain a deep understanding of the concepts. The FAC lecturer suggested that many of the students who encounter difficulties do so because of "how they learn or try to learn", that is due to their learning style and their approach to learning.

To understand if the failure rate for the FAC course is particularly high, the FAC course failure rate was compared to the failure rate of other similar courses. Table 1.1 compares the average failure rate of first year mathematical sciences major courses at Wits over a four-year period (2000 – 2003). The failure rate excludes those students who registered for the course, but did not write the examination.

Table 1.1 Comparison of the average failure rate for first year mathematical science major courses over a four-year period (2000 – 2003)

Course / Module	**Average Failure rate**
Computer Science: Basic Computer Organisation	41%
Computer Science: Data & Data Structures	19%
Computer Science: Limits of Computations	33%
Computer Science: Fundamental Algorithmic Concepts	48%
Computational & Applied Mathematics I	20%
Mathematics I (major)	31%
Actuarial Science I	34%
Mathematical Statistics I	36%

It is evident from this table that for this particular period the FAC course has had the highest failure rate. It must be noted that these figures are not directly comparable as the Computer Science courses/modules are given over a 6-7 week period whereas the other courses listed in the table are for the entire first year course. The School of Computer Science at Wits focuses on the student's marks for the individual modules, as if a student performs poorly in a particular module, he/she will not have sufficient grounding in the particular topic to continue with the topic in second year. Therefore, given the different approach followed by the School of Computer Science compared to the other mathematical departments, understanding why there is a high failure rate for the FAC course is important as students are prevented from proceeding with Computer Science if they perform poorly in this module / course.

1.3 Rationale for the Study

There are many reasons why students struggle with their studies, for example the numerous socio-economic and socio-cultural factors described by Bosa-Barlow (1999). For the purpose of this research project, a struggling student is a student who is working hard and making great efforts, but whose marks are borderline and therefore he / she is in danger of failing the course, but he /she appears to have the potential to pass. Factors such as studying in a second language, lack of parental support with studies and insufficient funds to purchase learning material have an influence on the students' ability to succeed but, for the purpose of this research project, this was too broad a base to examine. The focus of the research was therefore on two aspects that are under the lecturer's control, or at least can be influenced by the lecturer, in particular students' learning styles and learning approaches. These two concepts are described and discussed in some detail in chapter 3.

The rationale for the study is captured succinctly in two quotes from Ramsden (1992, pg 8):

- "To teach is to make an assumption about what and how the student learns; therefore to teach well implies learning about students' learning."
- "Good teaching involves striving continually to learn about students' understanding and the effects of teaching on it."

The FAC lecturer wants to learn about his students' learning, in particular their learning styles in order to meet the needs of all of the different students and thereby be a "good" teacher. The FAC lecturer also wants to understand the study approach used by the students studying FAC, in particular those students who struggle with the course, as it may be possible to provide some study skills advice to the students.

1.4 Aim of the Study

In an attempt to improve teaching, the intention was to improve the understanding of how FAC students go about learning. The aim of the study was therefore to investigate the learning styles and approaches of students studying the Fundamental Algorithmic Concepts Course at Wits. In order to do this, research was required to answer the

following questions. Particular attention was given to those students who struggled with the course.

1. What are the various learning styles of students studying the FAC course?
2. What are the learning approaches used by students studying the FAC course?
3. What, if any, relationship is there between learning approaches, learning styles and student success?

1.5 Overview of the Methodology

The research study was primarily exploratory in nature as a result of the research questions I was attempting to answer. A survey with a questionnaire was used to get a broad overview of the learning approach and learning styles of the FAC students. An ethnographic design with a semi-structured interview was used to provide an in-depth description of a purposively selected small sample of the FAC students. A predominately qualitative approach was used, supplemented with quantitative data. The results of the survey were analysed using descriptive statistics including correlation analysis as well as *t*-tests to determine the level of significance of the results. The responses to the interviews were categorised, analysed and synthesized.

1.6 Results

The study was undertaken to try and get some understanding as to why there is a high failure rate in the FAC course. The results of the research indicated that the adoption of a deep learning approach, which was encouraged by the lecturer, did not imply good grades. Contrary to the lecturer's anecdotal view, students who failed the course were not necessarily adopting a surface approach to their learning. It appears that a strategic learning approach may be required to achieve good grades.

From a learning style perspective, students who have a preference for a learning style that is different to traditionally predominant teaching styles are obtaining lower grades than those with learning styles matching traditionally followed teaching styles. For example, the large majority of the students have a preference for a visual learning style. However, traditionally the predominant teaching style favours verbal learners and there is some evidence that verbal learners achieved higher grades than visual learners. Active learners obtained lower course marks than reflective learners (p=0.02). Traditionally the

predominant teaching style favours those who are achieving better results, that is those with a preference for a reflective learning style.

In summary, the deep learning approach followed by many of the students may not be conducive to good grades and the teaching style of the lecturer may not accommodate the learning style preferences of many of the students. The lecturer can either adapt his assessment approach, or encourage the students to adopt a strategic approach to their learning. A combination of the two would probably be the most appropriate. In addition, the lecturer should pay particular attention to incorporating teaching styles that accommodate students with visual and active learning style preferences.

1.7 Organisation of the Report

In order to facilitate the reading of this research report, the way the chapters are linked together is shown in Figure 1.1. This first chapter contextualised the research by highlighting the relevance and importance of the study. In order for the reader to have some level of understanding of the FAC course, an overview of Computer Science and in particular the FAC course is provided in chapter 2. In chapter 3 the literature reviewed which informed the study is discussed according to a number of themes. Chapter 4 describes the research design and methodology followed as well as the instruments selected.

The data analysis and results are presented and discussed in chapters 5 to 7. By analysing the results of the two diagnostic tests, chapter 5 and chapter 6 examine the first two research questions: “what are the various learning styles of students studying the FAC course?” and “what are the learning approaches used by students studying the FAC course?”. In chapter 7 a deeper understanding is obtained on the students’ learning styles and learning approaches when the results from the interviews are analysed and discussed. In chapters 5 to 7 the third research question, “what, if any, relationship is there between learning approaches, learning styles and student success?” is examined. Finally, in chapter 8 the results of the previous chapters are drawn together and discussed and the findings and recommendations are presented.

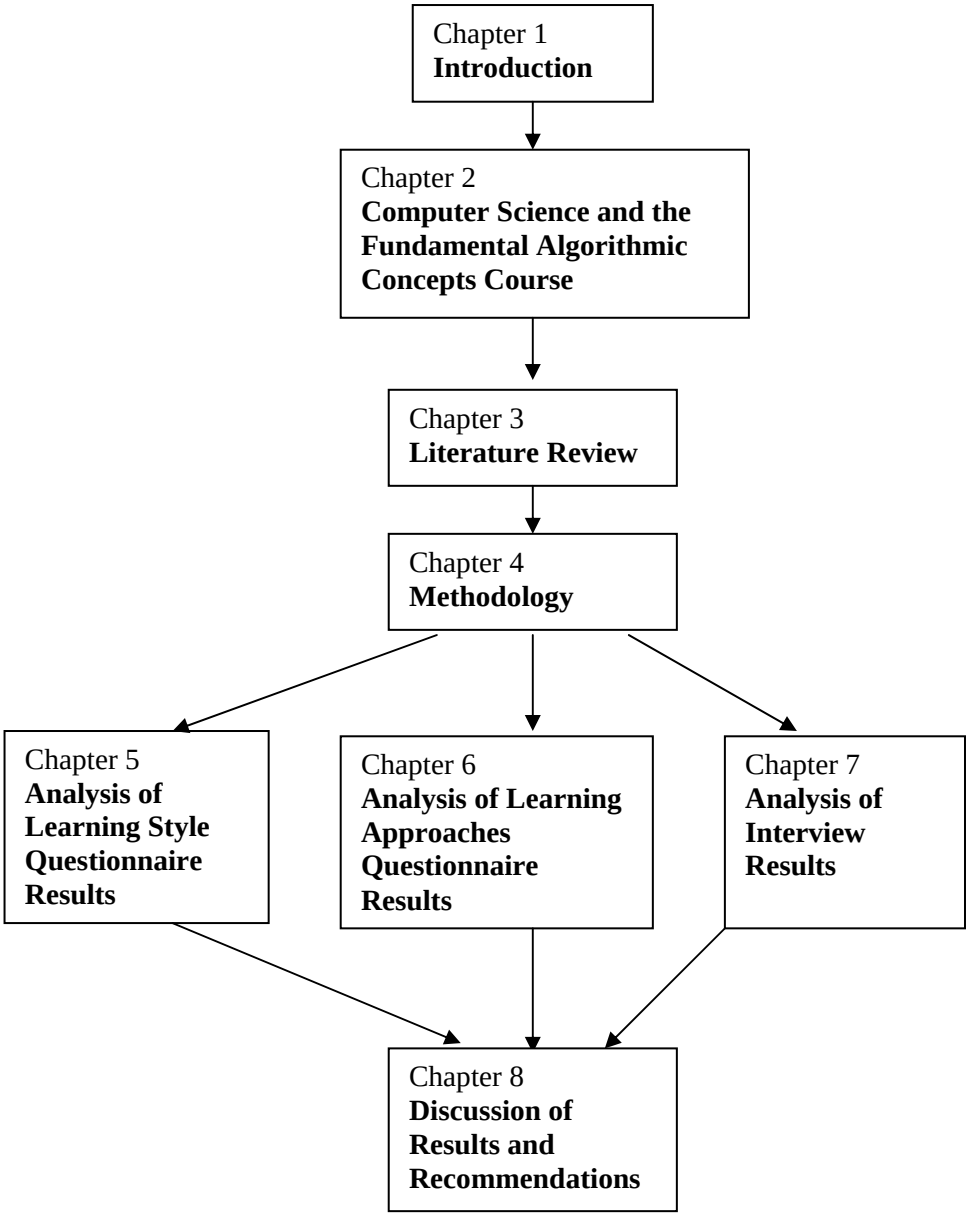

Figure 1.1 Linking of chapters

2. COMPUTER SCIENCE AND THE FUNDAMENTAL ALGORITHMIC CONCEPTS COURSE

2.1 Introduction

Although it has already been mentioned that the FAC course covers proof techniques and introduces some of the well-known algorithms and data structures and that it is a difficult conceptual course, a more detailed description of the aims of the course as well as the material covered is essential for a good understanding of the course and the research project. First, a high level overview of Computer Science is provided. Greater detail in the form of what topics are included in a computer science curriculum is then given. The topics covered in the first year computer science degree at Wits are elaborated on. The role of programming as well as prerequisites are then discussed. This is followed by a description on the particular area of interest, namely algorithms. Finally some detail of the FAC course at Wits is presented.

2.2 What is Computer Science?

There is a lot of debate about what Computer Science actually is. A classic paper on this topic is by Denning et al. (1989). This paper is condensed from the "Report of the ACM (Association for Computer Machinery) Task Force on the Core of Computer Science." Is Computer Science a science as its name implies, or is it an engineering discipline, or is it something else? For many the term Computer Science is synonymous with programming. Is this view correct? What is covered in Computer Science curricula? This debate is examined by considering some of the key characteristics of Computer Science.

Firstly, Computer Science cannot be regarded as a *physical* science as the principle objects of a computer scientists' study are man-made and not natural. However, as with all mathematical sciences, *theory* is a key characteristic of Computer Science. Denning et al. (1998) give many examples of theories that come out of a study of Computer Science, (for example: computability theory, computational complexity theory, automata theory), as well as theories from other disciplines that support areas of Computer Science (for example: graph theory, queueing theory and discrete mathematics).

However, Computer Science is not only grounded on theory, it also has a strong *experimental* component. Hartmanis (1995) notes that experimental work in the Computer Science world deals with performance measurements, evaluation of design methodologies and testing of new architectures.

Three characteristics of Engineering are: engineering is the *application* of scientific, or *mathematical* knowledge; *design* is an important characteristic of engineering; engineering is concerned with the *making* / manufacturing of useful things. From this perspective Computer Science can be viewed as an engineering discipline as:

- Computer Science is the *application of mathematical* knowledge.
- Denning et al. (1998) give a number of examples of *design* elements in the area of Computer Science, for example: cryptographic protocols; various computer languages; von Neuman machine; network protocols, et cetera.
- Computer Science, like engineering, does *produce* useful things, for example microprocessors and databases.

It has been argued above that computer science is both a science and an engineering discipline, but it is more than that, it also has its own unique characteristics. For example, Computer Science is not only the study of mathematical phenomena, Computer Science deals with something else, with things that are man made, for example information and / or data. Denning et al. (1988) note that computer science is a *unique blend* of the interaction of *theory*, *experimentation* and *design***.**

In summary, Computer Science is neither science nor engineering; it is a bit of both plus something all on its own. Computer Science has aspects that correlate with science and engineering, but it also has its own unique and distinctive characteristics. Wulf (1995, pg 56) succinctly summarises my views: "We (Computer Science) are science and engineering, and something more too."

The description above of Computer Science is fairly abstract. To provide additional insight, some of the topics included in a Computer Science curriculum, particularly a first year course in Computer Science, are described in the next section.

2.3 Computer Science Curriculum

Denning et al. (1989) describe nine areas covered in Computer Science. Although the Computer Science discipline has developed considerably over the past fifteen years, these areas are still relevant today. For each area a few typical questions are provided so that the reader can understand, from a practical perspective, what aspects are covered.

1. **Algorithms and data structures:** what type of problems can be solved and what type of problems cannot be solved with a computer? How much storage and time does a particular algorithm require? This area is discussed in more detail in section 2.7 below.
2. **Programming languages:** What notation / syntax can be used efficiently to specify what the computer should do? The role of programming is discussed in more detail in section 2.5 below.
3. **Architectures:** How do we design and organise hardware and software to provide efficient solutions?
4. **Numerical and symbolic computation:** How can computer scientists accurately approximate continuous or infinite processes by finite discrete processes?
5. **Operating Systems:** How can security be ensured? How can we operate over multiple systems over multiple geographies?
6. **Software methodology and engineering:** How do you know if a designed solution satisfies all the given specifications?
7. **Database and information retrieval systems:** How can text be indexed and classified for efficient retrieval? How should data be structured?
8. **Artificial intelligence and robotics:** How can we get a "computer" to learn from "experience"?
9. **Human-computer communication**: How can the computer recognise the human voice? How should systems be written to make it easy for users to know what to do?

An ongoing debate is when and how to introduce each of the areas listed above. In the next section, focus is given to a curriculum for first year computer science.

2.4 First Year Computer Science Curriculum

There is considerable debate on what topics should be included in a first year computer science curriculum. I have not included a comprehensive discussion on the subject, but

have discussed what topics have been included in the first year computer science curriculum in the School of Computer Science at Wits.

Sanders and Mueller (2000, pg 227), from the School of Computer Science at Wits, note that their aim is to offer a “good computer science degree” that is accessible to all students who have the potential to succeed. Three primary motives influenced the courses they chose to include in the first year:

1. To reduce the effect of the "growing gap between students with and without programming (and general computer) experience" (Sanders and Mueller 2000, pg 227).
2. To highlight what the study of computer science is about as early as possible in the student’s career.
3. To ensure that computer science students can develop and analyse algorithms.

Five courses are taught in the first year. The outline of the courses provided below is from Sanders and Mueller (2000). The first two courses, BCO and FAC, are taught in blocks one and two. DDS and LOC are taught in blocks three and four. The BCC course is taught throughout the year as one 45 minute lecture per week.

1. **Basic Computer Organisation (BCO):** Propositional logic, boolean algebra, relationship between logic and hardware, introduction into basic hardware building blocks, automata, simple von Neumann model, study low-level programs, overview of operating systems and networks, distributed systems.
2. **Fundamental Algorithmic Concepts (FAC):** This is discussed in section 2.8.
3. **Data and Data Structures (DDS):** Representation of data, data structures, recursion, dynamic data structures, verification, databases and graphics.
4. **Limits of Computation (LOC):** Halting problem, responsibilities of scientists and professionals, ethics, the implications technology has for South Africa, the values of computer science, the value of research, overview of Artificial Intelligence and the Theory of Computation.
5. **Basic Computer Concepts (BCC):** Introduction to a computer, Linux, email, syntax of the chosen programming language, translating an algorithm into code, desk checking, compilers, error detection, error correction, arrays, procedures, records, pointers and files, overview of databases, overview of networks, the use of the internet, markup languages, many exercises.

Although I have not explicitly linked the above courses with the areas described by Denning et al. (1989), it is evident that the material covered at Wits is aligned with the areas proposed by Denning et al. One topic that is not covered, that most people would expect to see in a first year Computer Science curriculum is programming. The role of programming is discussed below.

2.5 The Role of Programming

Denning et al. (1989, pg 11) comment that the "notion that 'computer science equals programming' is misleading." It is evident from the topics described above that many aspects of computer science are not programming. However, Denning et al. (1989, pg 11) comment that "clearly programming is part of the standard practices of the discipline and every computing major should achieve competence in it." Denning et al. (1989, pg 11) go on to emphasise that this does not "imply that the curriculum should be based on programming or that the introductory courses should be programming courses."

These comments of Denning et al. (1989) are aligned with the views of Sanders and Muller (2000). However, many first year computer science curricula include programming, therefore it is worth obtaining a clearer picture of how Professor Ian Sanders, the current (2004) lecturer of the FAC course and one of the authors of the paper "A Fundamentals-based Curriculum for First Year Computer Science" views programming.

In an interview in 2004, Professor Sanders noted that although they do not set out to try and teach programming as a topic, programming is viewed as an important vehicle for the students to use to test various concepts. For example, during tutorials students would use a programming language to implement an algorithm to see what happens when the data set gets very large. Professor Sanders also noted that at the end of a three year computer science curriculum, students would be able to program in about three or four different languages. Sanders and Muller (2000) deliberately decided to use an unusual programming language, namely Scheme, in laboratory sessions in order to reduce the gap between students with programming experience (usually Pascal or Java) and those with no prior programming experience.

Another aspect that should influence the first year curriculum is the background of students entering university. This includes prior computer experience as well as linguistic skills. This is discussed in the next section.

2.6 Prerequisites and Background of Students

Denning at al (1989) assume that students who seek to become computing majors already have a modest background in some aspects of computers and they recommend that a “remedial” course be provided for students who don't have an appropriate background. In the same vein Yahya (1992) notes that in the industrial countries some introductory computer science material is being covered in high schools, but that many “poorer countries” will be unable to introduce computer courses into their schools. For the third world countries Yahya's (1992) recommendations follow those of Denning et al. (1989) and Yahya (1992) recommends that first year courses take account of previous computer science training and that there should be introductory courses that students may need to take before entering the first year course.

This issue is relevant in the South African context, but with additional complexities due to the dual nature of the schooling system. Some students attend well-resourced schools and are able to take computer studies as a school subject, whereas other students attend poorer resourced schools. Some students have access to computers at home whereas other students do not even have electricity at home. This is linked to the concern of Sanders and Mueller (2000, pg 227) that there is a "growing gap between students with and without programming (and general computer) experience."

The recommendations of Denning et al. (1989) and Yahya (1992) of a remedial, introductory course are one possible solution to the problem. However, the School of Computer Science at Wits has chosen an alternative route. Sanders and Mueller (2000) comment that their aim is to offer a good degree that is **accessible** to **all** students who have the potential to succeed. Other than an acceptable grade in Mathematics (higher grade C which equates to above 60%), Sanders and Muller (2000) chose not to impose any computer knowledge or skills as a prerequisite and not to introduce an introductory course, but rather to adapt the curriculum so that all students start on an equal footing. In particular, as discussed above, they use a programming language that none of the students are familiar with and focus on giving the students an appreciation and broad

understanding of the computer science discipline. In addition, in 1999 they introduced a "Basics course to provide skills that many of the students may feel they lack" (Sanders and Mueller 2000, pg 229).

Following on from the discussion on computer experience as an influence on the first year curriculum, it is interesting to consider if there are any language issues that should be taken into account when designing a first year computer science curriculum. Yahya (1992, pg 125) notes that "major consideration must be given to gear the program to take into account the language skills of the potential audience."

At Wits the language of instruction in the Computer Science department is English. However, for many of the students this will not be their home language and this will need to be taken into account when teaching and setting assignments, for example the meaning of words within a particular context may need to be explained. This issue is not only a problem in Computer Science, but in many other disciplines.

In the next section, one particular topic covered in a computer science curriculum, namely algorithms, is discussed.

2.7 Algorithms

Algorithms are an essential component of Computer Science. Baldwin (1990, pg 58) comments "computer science is fundamentally the study of abstract computation (i.e. algorithms) rather than concrete mechanisms that carry out computations (i.e. programs or computers)."

Algorithms are part of the theory of computing, but most students struggle with learning them. Grinder et al. (2002) note that it can be tempting to forego teaching the theory of computing as most students struggle with it and seem to retain very little of what they are taught. However, Grinder at al (2002, pg 371) also comment that "the theory course puts the "science" into computer science, gives aspiring practitioners a basis for understanding the fundamental laws that govern their discipline: there are problems that cannot be

solved, there are intractable[1] problems, there are limitations on the efficiency of the solutions to problems, and so on."

In attempting to answer the question, "Why do we study algorithms?" Sanders (2004) provides the following reason, very similar to that provided by Grinder et al. (2002): "We study algorithms in order to be able to determine (for a given problem) whether an algorithm can be found to solve the problem, whether the problem can be solved in reasonable time and to be able to choose the "best" algorithm if more than one exists."

Therefore, even though most students struggle to learn algorithmic concepts, and many students expect computer science to be about programming rather than theory, it is the theory that provides a solid foundation and enables students in their computer career to move beyond programming and to become the leaders and thinkers in their fields, such as business analysts, computer graphic designers, software and hardware architects.

Since students struggle to learn algorithms, there are papers and books that discuss ways that algorithms could be taught to make them more accessible to students. Hubscher-Younger and Narayanan (2003, pg 6) comment that a qualitative study that they undertook indicated that "students regularly employ informal and collaborative meaning-building activities while learning algorithms." In this same vein, McConnell (2001) has written a book titled the "Analysis of Algorithms: An Active Learning Approach." This book presents the material with the expectation that it can be used with an active and cooperative learning methodology. The appropriateness of this teaching method will be reflected upon later in this report when discussing the results of the research.

There is a lot of research on the use of simulations or animations to help teach algorithms and related topics. For example, Kann et al. (1997) found that combining animation with the implementation of an algorithm was effective. Byrne et al. (1999) examine whether animations of algorithms would help students learn the algorithms more effectively. The results of their study suggested that encouraging students to predict an algorithm's behaviour might aid the students whether it is via animation or static diagrams. Jagielski (1988) reported that visual simulation helped students to better understand the concept of finite automata and regular expressions. There are contradictory views in this area;

[1] An intractable problem is a problem that is not practically computable, normally because of the excessive length of time required to calculate the answer.

therefore the benefits of simulations would need to be investigated for the FAC course at Wits.

In the next section, the topics covered in the FAC course in the School of Computer Science at Wits are outlined.

2.8 The Fundamental Algorithmic Concepts Course

There were three main topics covered in the FAC course taught in 2004:

1. Mathematical proof techniques
2. Graph theory
3. Algorithms

In table 2.1 the aspects covered under each topic are listed and some comments are made on what the students probably need to do to learn the topic. The comments under the learning technique were synthesised from an interview with the lecturer of the FAC course, Professor Ian Sanders, in 2004.

Table 2.1 Topics covered in FAC

Topic	**Aspects covered**	**Learning technique**
Mathematical proof techniques	• Direct proofs • Proofs by contradiction • Inductive proofs • Constructive proofs	• Need to abstract out a process to do the proof. • Need to practice many examples.
Graph Theory	• Basic definitions • Application of above mathematical proofs to graph theory • Trees (a restricted class of graphs)	• Memorisation • Practice and more practice • Memorisation of definitions and then the application thereof.
Algorithms	Various problems are covered including: • mathematical problems (e.g. calculating factorials • operations on binary search trees.	• Memorise the process and steps to follow. • Practice and practice a technique called tracing.

It became evident in discussions with the FAC lecturer that through constant practice, it should become intuitive for the student to know what to do in certain steps, for example the appropriate inductive step to use when proving a theorem using an inductive approach.

The aim of this chapter was to provide the reader with an understanding of what the subject computer science is about, and in particular what is covered in the FAC course at Wits. It is evident that computer science is not just programming and that an important aspect of studying computer science is studying the theory of computer science. Algorithms are part of this theory of computing and although the material is not easy, it is essential to provide a fundamental grounding in the science of computers.

With this background, it is now possible to discuss the theory of learning styles and learning approaches and the results of the research.

"A fancy name for a set of instructions like adding 2 and 2. Software uses algorithms, which spell out how to do the simplest things in painful detail, because computers are still a little, you know, dumb"

3. LITERATURE REVIEW

3.1 Introduction

In chapter 1 the study was contextualised by highlighting the relevance and importance of the research. In chapter 2 an overview of Computer Science and in particular the FAC course was provided. In this chapter the literature that informed the study is critically reviewed. Following this chapter, the selected methodology, based on the literature reviewed, will be discussed in chapter 4.

The most important thing about university learning is that it is supposed to prepare students for handling situations in the future (Bowden and Marton 1998). One of the aims of university education is therefore "critical thinking" (Entwistle and Ramsden 1983). The study of students' learning in university has developed as a research area in its own right in the past 25 – 30 years. There is therefore a vast amount of relevant literature on learning: learning strategies, learning approaches, learning styles, and so on. A complete review of all such literature was not possible for this research project; therefore this chapter focuses on the literature that was critically reviewed to inform the research.

In this chapter, the first focus is to define learning. Then, given the various uses of the terms "learning styles" and "learning approaches", the next focus is a definition and description of these terms and related concepts. These theoretical frameworks are covered in section 3.2. In section 3.3 findings from the various studies are reviewed and discussed according to five themes.

Additional topics associated with learning styles and learning approaches are briefly covered in section 3.4. Due to the limited scope of the study, only one or two papers were consulted on each topic to provide some insight and background. The risk of this method is that different views of researchers on a particular topic are not exposed.

3.2 Definitions and Theoretical Frameworks

There are a number of theoretical frameworks that could be used to explore how students go about learning. On reviewing the literature it was evident that the theoretical

framework of learning styles had been used by researchers in the computer science discipline and was therefore selected as an appropriate framework for this study. Apart from Booth (1992) there is little reference to learning approaches in the literature on computer science education. However, in literature on higher education, “approaches to learning” has been extensively used to conceptualise learning. It was therefore decided that research into learning approaches could possibly provide valuable insight into why students are not succeeding in the FAC course.

The term “learning strategies” is also used throughout the literature. To contain the scope of the study I decided not to investigate learning strategies as a separate framework, but to refer to those learning strategies that are of particular relevance within the frameworks of learning styles and learning approaches, for example the holist and serialist strategies (Entwistle in Schmeck 1988).

The first focus of this section is to define “learning” (section 3.2.1). Then, given the various use of the terms “learning styles” (section 3.2.2) and “learning approaches” (section 3.2.3) the next focus is to define and describe these terms and related concepts. Next, the key differences and similarities between learning styles and learning approaches are discussed (section 3.2.4). This is followed by a brief discussion on learning strategies (section 3.2.5) and then two particular strategies: a serialist strategy and a holist strategy are described (section 3.2.6). Finally a brief description of some pathologies of learning (section 3.2.7) is provided.

3.2.1 Learning

Learning can be defined from a number of perspectives: the experiential or phenomenological perspective, the behavioural perspective and the neurological perspective (Schmeck 1998). When referring to learning styles and learning approaches, the primary perspective used is a phenomenological perspective. The learning is described by the individuals engaged in the learning process. The focus of the phenomenological approach is to “step back from ordinary assumptions regarding things and to describe the phenomena of experience as they appear rather than to attempt to explain why they appear that way” (Marton 2004, pg 1). Phenomenography is a branch of phenomenology. Phenomenography “aims to identify the qualitatively different ways in which people experience, conceptualise, perceive and understand various kinds of

phenomena. It describes learning as experiencing situations in the world in particular ways" (Entwistle 2004, pg 1). Booth (1992) emphasises that an important aspect of the phenomenographic approach is the content and context of the learning. "Learning is always learning *something"* (Booth, 1992, pg 53).

Although I have considered the learning style models and learning approach models to be primarily phenomenographic in nature, it must be noted that this perspective is not fully shared by all researchers. For example Marshall and Case (2003, pg 4) make the following comment: "we would consider inventory research to *not* be phenomenography. Furthermore, we think it is important to recognise that there are qualitative researchers in the approaches to learning field who do not consider their work to be phenomenographic."

For both learning styles and learning approaches, learning from a behavioural perspective is also important as it is only through observable change that we can see if learning has occurred. As Ramsden (1992, pg 4) notes "learning in educational institutions should be about changing the ways learners understand, or experience, or conceptualise the world around them." However, it is important to note that an individual's learning style or approach cannot be inferred from the individual's behaviour. This is discussed in more detail below, under learning approaches. Learning considered from a neurological perspective, and the way facts can be effectively stored and retrieved if they are embedded within the overall framework of the individual, is important when considering deep and surface learning approaches.

Therefore, although when referring to learning styles and learning approaches, primarily a phenomenological / phenomenographic perspective will be taken, various perspectives of learning are important if one is to consider learning styles and learning approaches from a holistic viewpoint.

3.2.2 Learning styles

Put simply, a learning style is the way or method an individual prefers to gather and absorb data – the way an individual takes in or receives and processes information. Learning styles are relatively stable indicators of how learners perceive, interact with and

respond to the learning environment. Some authors give a fairly narrow definition of learning styles. For example, Wyman (2004) refers to three primary learning styles; namely visual (through pictures), auditory (through sounds) and kinaesthetic (through feelings or touch). Others, for example Hermann, referred to by Schmeck (1998), classify individuals based on the specialised functioning of the physical brain - an individual may be primarily left or right brained, cerebral or limbic. Schmeck (1988) refers to cognitive style as the stable, traitlike consistency in attending, perceiving and thinking.

I have not come across a recent paper or book that provides a history of the theory of learning styles. However, it is evident that learning styles have been the focus of a considerable number of studies for a number of years. Claxton and Murrell (1987, pg 3) comment "that people learn differently is certainly not a new idea. Many inventories of learning style lead to conclusions that were formulated (for example by the Hindus) over 2,500 years ago". The evolution of the study of learning styles can be traced back to work such as Carl Jung's work on "psychological types".

Some of the names synonymous with learning styles are: Kolb (1984), Honey and Mumford (1982), Gregorc (2004) and Felder (2002). One of the early papers in the Computer Science education literature on learning styles is by Feyock and Ford (1976) on "Individual learning styles and computer science education". Feyock and Ford (1976) discuss two primary learning styles: serialist and holist. These two "styles" or strategies were formulated by Pask (in Schmeck 1988; Entwistle and Ramsden 1983) and are described below in section 3.2.6 as they appear to overlap with both learning approaches and learning styles.

In 1988, Richard Felder and Linda Silverman formulated a learning style model designed to capture the most important learning style differences amongst engineering students and provide a good basis for engineering instructors to formulate a teaching approach that addresses the learning needs of all students (Felder and Spurlin 2005). For the remainder of the report I use the term "learning style" to refer to the four dimensions defined by Felder (1996): Active / Reflective; Sensing / Intuitive; Visual / Verbal; Sequential / Global. "The ways in which an individual characteristically acquires, retains, and retrieves information are collectively termed the individual's learning style" (Felder 1995,

pg 21). The four dimensions of the Felder-Silverman Learning Style Model are delineated in Figure 3.1 (Howard et al. 1996, pg 228).

Definitions	Dimensions		Definitions
Do it	***Active***	***Reflective***	Think about it
Learn facts	***Sensing***	***Intuitive***	Learn concepts
Requires pictures	***Visual***	***Verbal***	Require reading or lecture
Step by step	***Sequential***	***Global***	Big picture

Figure 3.1 Felder-Silverman Learning Style Model

The Felder-Silverman model classifies students as having preferences for one category (for example active) or the other (for example reflective) in each of four dimensions (for example active / reflective). The explanations provided below of each category are largely from Felder and Silverman (1988), but are also taken from various other papers, for example Felder and Spurlin (2005), Chamillard and Karolick (1999).

Active / Reflective:

Active: learn best by doing something, try things out, discuss the material, enjoy working in groups, tend to be experimentalists.

Reflective: learn by thinking things through, prefer working alone or with a single familiar partner, tend to be theoreticians.

Sensing / Intuitive

Sensing: like to memorise facts and solve problems using well-established methods, dislike surprises, concrete thinker, practical, patient with details but do not like complications, careful but may be slow.

Intuitive: abstract thinker, orientated towards theories, principles and underlying meanings, like to discover relationships and use innovative problem-solving approaches, good at grasping new concepts, dislike learning facts and repetition, bored with details, quick but may be careless.

Visual / Verbal

Visual: remember best what they see such as pictures, diagrams, flow-charts.

Verbal: remember much of what they hear or read.

Sequential / Global

Sequential: Understand in small, linear, logical steps.

Global: holistic thinking process, learn almost random pieces of material and then suddenly "get it", make intuitive leaps and may be unable to explain how they came up with solutions.

The Index of Learning Styles (ILS) is an instrument designed by Felder and Soloman (2004a) to assess preferences on the four dimensions of the Felder-Silverman Learning Style Model. This index is discussed in chapter 4.

Before discussing some of the applications of the learning style model in section 3.3, some definitions and theory on learning approaches and related topics are provided in the following sections.

3.2.3 Approaches to learning

I have used the terms "approaches to learning" and "learning approach" as used by a number of researchers, such as: Marton and Säljö (1984); Biggs (1987); Ramsden (1992); Entwistle (2004). A learning approach is about **what** students do when learning, **how** they do it (the process), and **why** they do it (motivation and intention), rather than about how much they learn (Ramsden 1992; Case and Gunstone 2002). Entwistle (2004) and Biggs (in Schmeck 1988) particularly emphasise the importance of why a student is learning, that is a student's motives and intentions.

Although some of the inventories used to measure approaches to learning measure a general approach adopted by the students, some researchers, in particular Ramsden (1992) and Bowden and Marton (1998) emphasise that the context is critical and that students may adopt different approaches in different contexts. "Approaches to learning describe the

relation between the learner and the object of learning within a particular context" (Bowden and Marton 1998, pg 61). I have generally followed this perspective when referring to approaches to learning, but this topic is commented on further in section 3.2.4 below.

A number of writers provide some historical background on the research on approaches to learning and studying in higher education, for example Regan and Regan (1995). The literature that I found particularly useful in this regard is by Richardson (2000). Research began in the 1970s at the University of Gothenburg in Sweden. I have not sought to provide any detail in this literature review on the historical background, but provide the above references for those who wish to read further.

Given the widespread popularity of the term "approaches to learning" and with this popularity a degree of misuse of the terms, it is worth summarising what an approach is **not**:

- An approach is not a characteristic of an individual. As stated by Ramsden (1992, pg 49) "one cannot be a deep or surface learner; one can only learn the concept in a deep or surface way."
- It cannot be inferred from a student's observable behaviour (Ramsden 1992),
- An approach is not about how much you learn and one can not equate low ability to surface approaches (Ramsden 1992),
- "Approaches to learning do not describe developmental stages through which learners pass" (Marshall and Case 2003, pg 2),
- Approaches to learning are not synonymous with learning strategies. Certain strategies may be prevalent with certain learning approaches and this is discussed in section 3.2.6 below, and
- "Approaches to learning are not synonymous with learning styles" (Marshall and Case 2003, pg 2). The similarities and differences between learning styles and learning approaches are discussed in section 3.2.4 below.

Now that I have described what an approach to learning is not, it is important to understand in greater detail what it is. There are two primary approaches to learning, namely a surface approach and a deep approach (Ramsden 1992; Entwistle in Schmeck 1988; Biggs in Schmeck 1988).

A student using solely a **surface approach** to learning tends to *memorize* facts and procedures and reproduce parts of the content without obtaining a deep understanding of the whole – an **atomistic** process (Ramsden 1992; Entwistle and Ramsden 1983). These students tend to be at university in order to obtain a qualification with minimum effort (Biggs in Schmeck 1988). However, some students expend a lot of effort, but still have a superficial understanding of the material as they focus on the facts, formulas and figures rather than understanding the concepts (Bowden and Marton 1998). In a study of second year Chemical Engineering students Case and Gunstone (2002) identified two forms of surface approaches. These two forms, an algorithmic approach and an information-based approach, are particularly relevant for studies in the engineering and science fields including the FAC course. In an algorithmic approach, "students focus on remembering solution methods" (Case and Gunstone 2002, pg 460). In an information-based approach "students focus on remembering specific pieces of information" (Case and Gunstone 2002, pg 460).

Students using a **deep approach** focus on what the task is about with the intent of personally *understanding* the material and actively relating the ideas to previous knowledge and experience, thereby adopting a **holistic** approach (Ramsden 1992). These students tend to have a fundamental interest in the task (Biggs 1987; in Schmeck 1988). Case and Gunstone (2002) refer to the conceptual approach, which is fairly similar to a deep approach.

McCune and Entwistle (2000) also refer to a **strategic approach** that is similar to the **achieving approach** described by Biggs (in Schmeck 1988). The student who adopts the strategic or achieving approach is concerned with achieving grades that are as high as possible and is therefore organised in his/her studies and focuses on time management and employing the "best" approach for the task at hand.

The approaches to learning adopted by students are related to a number of factors. As noted earlier, Entwistle (2004) and Biggs (1987; in Schmeck 1988) emphasise the importance of why a student is learning, specifically a student's motives and intentions. Entwistle (in Schmeck 1988, pg 22) explains the terms intrinsic motivation and extrinsic motivations as "a distinction between learning for personal understanding or development and learning necessitated by fulfilling the requirements of others in completing academic tasks to defined standards." A table provided by Entwistle (in Schmeck 1988, pg 23)

showing the aims and concerns of students with various extrinsic and intrinsic orientations is provided in Appendix A, Table A1. A table provided by Biggs (1987) summarising the association between a student's learning approach, motive and learning strategy is provided in Appendix A, Table A2. These tables were consulted when analysing the interviews. This is discussed in section 7.2.1

Learning styles and learning approaches have been described above from an independent and discrete perspective. However, it is also important to understand the interplay between these concepts and the key differences and similarities between them.

3.2.4 Similarities and differences between learning styles and learning approaches

A learning style resides within an individual and an individual will probably display the same learning style across many situations. Learning styles relate to genetics and prior experience and there is an inherent continuity aspect to learning styles (Schmeck 1988). In contrast, a learning approach refers to the behaviours of a particular individual in a particular situation. Individuals may display different learning approaches depending on the particular situation (Schmeck 1988; Ramsden 1992). However, Ramsden (1992, pg 51) has noted that "general tendencies to adopt particular approaches" do exist and "variability in approaches thus coexists with consistency".

A teacher or lecturer may adapt his or her teaching style to accommodate the various learning styles of various individuals. This is not to say an individual cannot and should not learn how to cope with various teaching styles, but that they will do better if the teaching style matches their learning style. When referring to learning styles, the location of control in accommodating various styles is more with the lecturer than with the individual student (Felder and Silverman 1988; Felder 1995). One role of the lecturer is "to balance the instruction, so that each student is sometime taught in a matching style (which keeps them from being too uncomfortable to learn) and sometimes in a mismatched style (which helps them develop skills in areas they would ignore if they had the choice" (Richard Felder, personal communication, 13 June 2004).

When examining learning approaches, the student is in control of the approach he or she decides to use. This is not to say that the lecturer cannot influence the approach taken by the

students, as the lecturer has control of important aspects of the situation and can thereby influence the approach taken by the student by changing the situation, for example setting tests that encourage rote learning of facts or understanding of the concepts. Therefore, from the perspective of learning approaches, one of the roles of the lecturer is to enhance meta-cognition in the students and make them aware of their learning approaches in order that they may monitor and expand upon them. The role of the lecturer with regards to learning styles and learning approaches is discussed further in section 3.3.2 below.

When researchers refer to learning styles, there tends to be no judgement made on what is a "good" or "bad" learning style (Felder and Soloman 2004a). On the other hand, most writers (Entwistle in Schmeck 1988; Ramsden 1992) seem to assume that a deep learning approach is the "ideal", "best" approach that should be encouraged in tertiary education. However, in a recent paper Haggis (2003) questions whether the goals and values of a deep approach are not "elite" and not relevant for mass higher education.

In the next section the term "learning strategies" is defined. This is followed by a description of the serialist and holist learning strategies, which have some association with learning approaches as well as the sequential / global dimension of the Felder-Silverman learning style model.

3.2.5 Learning strategies

The term "learning strategies" is used throughout the literature. It tends to refer to the implementation of a sequence of steps or procedures by a learner to accomplish some form of learning (Schmeck 1988). There are a large variety of learning strategies ranging from planning one's time and memorisation, to self-testing and revising work (Turmo 2004). Literature on learning strategies has not been reviewed in any detail and the term "learning strategies" is used when describing the steps and procedures adopted by learners. A serialist strategy and a holistic strategy to learning are briefly described in the next section.

3.2.6 Serialist and holist strategy to learning

A number of authors, in particular Entwistle (in Schmeck 1988) and Entwistle and Ramsden (1983) refer to the research and findings of Pask. Pask (in Schmeck 1988)

describes two learning strategies, a serialist strategy and a holist strategy. (This holist strategy is not to be confused with the holistic approach discussed above.)

A serialist strategy is dependent on **operation learning**, where there is a linear and step-by-step progression from one assumption or fact to another. The process used in a holist strategy is called **comprehension learning** where there is a global focus and properties can be combined and understood simultaneously. As individuals tend to *consistently* adopt one or other strategy, Entwistle and Ramsden (1983) refer to operation learning and comprehension learning as styles. Operation learning and comprehension learning are very similar to the sequential / global learning style dimension described by Felder (1995). However, I have chosen to distinguish these two styles / strategies as they are so aligned with learning approaches.

There could be a temptation to associate operation learning with a surface learning approach and comprehension learning with a deep learning approach. However, operation learning is particularly evident in the "sciences" and comprehension learning in the "arts". In addition, Entwistle (in Schmeck 1988, pg 26) notes that "academic learning in higher education generally seems to demand both of these learning processes – a **versatile** style of learning".

Case and Gunstone (2002, pg 460) refer to an "algorithmic approach, in which students focus on remembering solution methods". The algorithmic approach to learning appears very similar to the operation approach to learning. However, Case and Gunstone (2002) view an algorithmic approach as a form of a surface approach whereas Entwistle (in Schmeck 1988) views operation learning as a form of a deep approach. This apparent contradiction will be explored in chapter 7 when analysing the interviews.

Entwistle (in Schmeck 1988) provides a model of the relationships between motivation, process and outcome. (This model was developed by Entwistle in collaboration with Dr David Newble, University of Adelaide). This model which summarises many of the aspects discussed above on learning approaches is provided in Appendix A, Figure A1. The model shows operation learning and comprehension learning as falling under deep learning. However, if a student adopts one of these processes to the exclusion of the other, they will reveal pathologies of learning. Two particular pathologies of learning are defined in the next section.

3.2.7 Learning pathologies

According to Entwistle (in Schmeck 1988) and Entwistle and Ramsden (1983), Pask describes two major learning pathologies: globetrotting and improvidence.

- **Globetrotting** is when a student repeatedly adopts a holistic strategy and focuses only on building up an overview. Globetrotting is often "associated with an over-readiness to reach conclusions without examining the supportive evidence" (Entwistle in Schmeck 1988, pg 26).
- **Improvidence** is when a student relies too much on a serialist strategy and "fails to make use of valid and important analogies and may not build up for himself any overall map to see how the various elements of the topic interrelate and how the topic fits into the subject area in general" (Entwistle and Ramsden 1983, pg 26).

In the next section some papers that refer to the application of the theoretical frameworks and models discussed in this section are reviewed.

3.3 Application of the Theoretical Frameworks

There are a large number of papers that describe and discuss the application of the theoretical frameworks of learning styles and learning approaches. The primary focus of the literature review was on papers that: (a) related to the computer science discipline; and / or (b) had a sample population from South Africa; and /or (c) referred to the Felder-Silverman Learning Style Model or used the ILS; and (d) referred to or used the concept of learning approaches. The results and findings from these papers are critically reviewed according to the following themes:

1. The relationship between learning styles or learning approaches and **student outcomes** (section 3.3.1).
2. The effect of the **teaching environment** and what lecturers can do (section 3.3.2).
3. The relevance of a particular **discipline** (section 3.3.3).
4. The relevance of **demographics** (section 3.3.4).
5. Learning style preferences and learning approach profiles (section 3.3.5).

3.3.1 Relationship between learning styles/approaches and student outcomes

Is there any relationship between the learning style or learning approach used or adopted by students and the outcomes observed? In particular is there a relationship with the student's level of achievement at university? The findings revealed in the literature are presented below.

Learning style and student outcomes

There is some evidence that there is a relationship between computer science students' learning styles and their success rate. The findings from four studies are described below.

Thomas et al. (2002) researched the implications of different preferred learning styles, measured with the ILS, on students' performance in the introductory programming sequence at the University of Wales. They found that there were significant differences in the academic performance of students depending on their learning styles. Reflective learners scored higher than active learners (p=0.015); intuitive learners scored higher than sensing learners (no statistical significance); verbal learners scored higher than visual learners (p=0.027) and sequential learners scored higher than global learners (no statistical significance). Thomas et al. (2002, pg 33) comment that the results could be interpreted in either of two ways:

- "Some students' learning styles are more suited to learning programming than others"

  or

- The "current methods of teaching advantage students with certain learning preference styles."

This second interpretation by Thomas et al. (2002) is aligned to the views of Felder (2004a) and is discussed below under the theme on the effect of the teaching environment.

Finnie (1987) describes an experiment performed to relate specific learning style profiles to aspects of the use of a computer model (a decision support system). Finnie (1987) used Kolb's Learning Style Inventory, (a well known instrument available to assess learning styles), to determine the learning styles of undergraduate business administration students at the University of Natal, South Africa and found that:

- "Successful users (of the decisions support system) rated higher on reflective observation than did unsuccessful" Finnie (1987, pg 5).
- "Users who rate highly on the active experimentation mode tend to use the "help" facilities while the reverse holds for those rating higher on reflective observation" Finnie (1987, pg 6).
- "Subjects emphasising the concrete experience (sensing) learning mode over the abstract conceptualisation (intuitive) mode had a higher error rate than those placing more stress on abstract conceptualisation (intuitive)" (Finnie 1987, pg 8). The learning dimension in brackets is the term used by Felder for a similar, but not equivalent, style to that used by Kolb.

Chamillard and Karolick (1999) examine if there is any correlation between learning style and academic performance. They also discuss how learning style data can be used to help guide student study habits and instructional strategies. The population group is an introductory first year computer science course at the U.S. Air Force Academy. Three learning style instruments and one personality model were used to collect the data. Two of the instruments used were Felder's ILS and Kolb's Learning Style Inventory. Chamillard and Karolick (1999) found that:

- Kolb's abstract conceptualisation (similar to Felder's intuitive dimension) had a strong correlation with the course performance scores, that is, abstract learners tend to perform better in the course.
- According to scores from Felder's ILS, "reflective students tend to do better in the course than active students" Chamillard and Karolick (1999, pg 295).

Van Zwanenberg et al. (2000) administered the ILS and Honey and Mumford's Learning Style Questionnaire to undergraduate students at two UK universities, one group studying engineering and the other group business subjects. Van Zwanenberg et al (2000) found that:

- There was a lack of significant correlations between learning style scores (preferences) and academic performance. This is in contrast to the findings of the three studies discussed above.
- "None of the correlations between ILS scale scores and performance has a value greater than 0.18 and, again, none is anywhere near significance" (Van Zwanenberg et al. 2000, pg 378).

- Referring to results from Honey and Mumford's Learning Style Questionnaire Van Zwanenberg et al. (2002) found that reflectors failed fewer units than activists.

In summary there is evidence of some correlation between certain learning styles and performance. In particular reflective learners tend to perform better than active learners. However, it is stressed by a number of authors including Felder and Spurlin (2005) and Van Zwanenberg et al. (2000) that the ILS must not be used to predict students' grades or as a selection tool.

Learning approach and student outcomes

Entwistle and Ramsden (1983) refer to the Gothenburg studies and the analysis done by Svensson where he shows that there is a close relationship between adopting a deep approach and passing examinations. Svensson also showed that students adopting a deep approach tend to spend longer studying than those adopting a surface approach (Entwistle and Ramsden 1983).

According to Ramsden (1992) there is evidence that students who adopt a deep, holistic approach to learning find learning more enjoyable and achieve better marks than those who adopt a surface, atomistic approach. "Deep approaches are related to higher quality outcomes and better grades. They are also more enjoyable. Surface approaches are dissatisfying; and they are associated with poorer outcomes" Ramsden (1992, pg 53). Biggs (1987, pg 70) reported similar findings: "we have found that a surface approach is associated with poor academic performance in general".

Booth (1992) found some relationship between the approach adopted to solve a programming problem and examination results. Booth (1992) investigated students studying an introductory course in programming. The study was fundamentally exploratory and a phenomenographic research tradition was followed. Research material was collected from the comments made by first-year students while they were studying two typical textbook problems. These problems were presented to the students during two interviews. The researcher also asked the students questions and retained copies of their solutions (Booth 1992). A tendency was seen where those who adopted a deep approach to solve the problem succeeded better in the exam than those who adopted a surface approach. "All evidence indicates that the structural and operational approaches (deep approaches) are the most likely to bring about successful learning" (Booth 1992, pg 234).

In contrast to the above findings, in a study carried out by Case (2004a) where inventories were used, there appears to be little relationship between the reported approach adopted and examination results. The investigated population were students studying a third year chemical engineering course at the University of Cape Town, South Africa. Approximately 25% of the students failed the course. This is a smaller percentage than the percentage failing the FAC course, but the FAC course is a first year course and the chemical engineering course is a third year course. The Approaches to Learning and Studying Questionnaire, which is a shortened version of the original ASI (Approaches to Studying Inventory) developed by Entwistle, was the selected questionnaire (inventory). A Likert-type scale is used in this questionnaire and students are asked to agree or disagree with questions posed.

The following findings are reported by Case (2004a):

- A high homogeneity in responses, indicating primarily a deep approach to learning, by a group of students that achieved a heterogeneous set of course results. This raises the question why students who indicated they were adopting a deep approach failed the course. Case (2004a) suggests that it could indicate that students gave what they consider the "right" answers even if it does not correspond with what they actually do.
- Many students who had indicated through their responses to the questionnaire that they were not adopting a deep approach had not failed the course. From an interview with a student, Case (2004a) speculates that this could be as a result of the student not understanding the questions, as the student's home language is not English.

In a similar vein to that of Felder and Spurlin (2005) and Van Zwanenberg et al. (2000) who caution against the incorrect use of the results of the ILS, Case (2004a) advocates that lecturers should be cautious in their use of the results of learning approach inventories.

In summary, Entwistle and Ramsden (1983), Biggs (1987) and Ramsden (1992) all report on the relationship between better grades and a deep learning approach. From the predominately qualitative study carried out by Booth (1992), some relationship between approach to learning and examination results is also evident. However, in the study carried out by Case (2004a) where inventories were used, there appears to be little

relationship between the reported approach adopted and examination results. Haggis (2003, pg 93) also comments that "a surface approach can lead to very successful learning in terms of results".

The theoretical frameworks suggest that a deep learning approach "should" be associated with better grades, but no particular learning style "should" be associated with better grades. In spite of this, why do students who adopt a deep approach fail to achieve good results? Why are some learning profiles associated with better grades? Some of the possible answers to these questions are proposed in the following section when the effect of the teaching environment and what lecturers can do are discussed.

3.3.2 Effect of the teaching environment and what the lecturer can do

What does the reviewed literature indicate can be done by the lecturer to accommodate the different learning styles of students as well as encourage the students to adopt a deep learning approach?

Learning style and the teaching environment

Felder (1992) puts the principal burden of responsibility for poor results by students on the educational system and not the students. He comments that what is needed is inspired educators and quality resources. Felder (2004a) notes that when mismatches exist between the teaching style of a lecturer and the learning style of students "the students may become bored and inattentive in class, do poorly on tests, get discouraged about the course, the curriculum, and themselves, and in some cases change to other curricula or drop out". Felder and Silverman (1988, pg 674) note further that "how much a given student learns in a class is governed in part by that student's native ability and prior preparation but also by the compatibility of his or her learning style and the instructor's teaching style". Based on the reviewed literature, what the lecturer can do to mitigate this situation is discussed below.

According to Felder and Spurlin (2005, pg 110), the ILS has two principal applications. "The first is to provide guidance to instructors on the diversity of learning styles within their classes and to help them design instruction that addresses the learning needs of all their students". The second application is to give students insights into their possible learning strengths and weaknesses.

Based on the second application, Chamillard and Karolick (1999) used the learning style data they collected to recommend suitable study habits for each student dependent on their learning style, for example “if you are a visual learner, it might help to diagram your problem solutions to check them before coding” Chamillard and Karolick (1999, pg 293). Felder and Soloman (2004b) give advice on how each “type” of learner can help themselves. For example, “If you are an active learner in a class that allows little or no class time for discussion or problem-solving activities, you should try to compensate for these lacks when you study. Study in a group in which the members take turns explaining different topics to each other. Work with others to guess what will be asked on the next test and figure out how you will answer” (Felder and Soloman 2004b, pg 1). Felder and Spurlin (2005, pg 105) stress that students need to be assured that their learning style preferences are not “reliable indicators of what they are and are not capable of doing, and that people with every possible learning style can succeed in any profession or endeavour.” The remainder of this section focuses on the first application - providing guidance to the lecturer.

The question then is, does the lecturer adapt his / her teaching style to accommodate the learning style of the majority of the students in the class? Claxton and Murrell (1987, pg iii) note that “some studies show that identifying a student’s style and then providing instruction consistent with that style contribute to more effective learning. In other instances, some mismatching may be appropriate so that students’ experiences help them to learn in new ways and to bring into play ways of thinking and aspects of the self not previously developed. … Knowledge of learning style can thus help faculty design experiences appropriate to students in terms of matching or mismatching and enable them to do so thoughtfully and systematically.”

These views expressed by Claxton and Murrell (1987) are highly aligned with the views expressed by Felder (1993; 1996). Felder (1996) encourages instructors to teach to all the learning style types. “If professors teach exclusively in a manner that favours their students’ less preferred learning style modes, the students’ discomfort level may be great enough to interfere with their learning. On the other hand, if professors teach exclusively in the students’ preferred modes, the students may not develop the mental dexterity they need to reach their potential for achievement in school and as professionals” (Felder 1996, pg 18). Although this review does not cover any papers that report on studies that

show that students learn more or achieve better results if they are taught in their preferred learning style, Felder (1993) refers to one such paper by Edward Godleski and Felder and Henriques (1995) refer to a few such papers.

Therefore, there are times that the lecturer must aim to accommodate the learning styles of his / her students; this is especially the situation when the material is new to the students. By analysing students' course performance and learning styles Chamillard and Karolick (1999, pg 294) used the data to "help guide instructors' teaching strategies so they can more effectively reach a wide range of students' learning styles". For example, for one instructor, it was found that active learners tend to do better than reflective learners. It was suggested to the instructor that he build more "reflection" time into his lectures. However, there are times when the lecturer must encourage the students to use a variety of learning styles.

Therefore, for theoretical and practical reasons, in essence the recommendation is to "teach to all the learning style types", also referred to as "teaching around the cycle" Some examples of this method, from a number of researchers, are provided below.

Felder (1993) notes that the quality of science education could be significantly enhanced if instructors modified their teaching styles to accommodate the learning styles of all the students in their classes. Felder (1993) goes on to give a number of practical suggestions for example "to illustrate abstract concepts or problem-solving algorithms, use at least one numerical example (sensing category) to supplement the usual algebraic examples (intuitive category)".

Some more practical advice is provided by Howard et al. (1996) who provide a course "blueprint". For example, start by explaining to the students why the material is being studied. "This gives Felder's global learner the big picture before the instructor steps through the material in the style that the sequential learner prefers" Howard et al. (1996, pg 229). To accommodate the active learner, some hands-on time was given on the computer during each class. And to accommodate the reflective learner, the lecturer would ask a group to present their solution to a problem, this would give the reflective learners a moment to pause and consider the subject without the lecturer moving onto new material. The aim of the paper by Howard et al. (1996) was to provide some practical

advice to lecturers and so unfortunately there is no reported research that can inform on whether the advice given improved the students' learning.

From a slightly different, but related angle, Hill et al (2003, pg 182) advise that "because students have different learning styles, it is important to incorporate multiple teaching techniques into the classroom experience". Lecturers can reach more students if they use a variety of instructional techniques. A technique used by Hill et al (2003) is the incorporation of hands-on exploration in class through the use of games. Hill et al (2003) found that although most students liked the use of games they did not perform well when evaluated. In addition they found that not all students liked the use of the games and suggested that "the game format was not appropriate for those particular students' favoured learning style" (Hill et al 2003, pg 185). Unfortunately Hill et al. (2003) did not back up this suggestion with any evidence, that is no correlations were provided between students' learning styles and their like or dislike of the use of games. Then again, Hill et al (2003, pg 186) note that a future challenge is to develop a mechanism for determining which learning styles are associated with responding well to the use of games.

In conclusion, the literature suggests that the teaching method should accommodate all learning styles. Lewandowski and Morehead (1998) who describe presentation strategies they have used with a computer science first year class, report that their "experience in the CSI (Computer Science I) course indicates that it is possible to create a lively, interactive class that encourages all students regardless of major, previous experience, or learning style to be active learners, to become problem solvers, and to take an interest in computer science" (Lewandowski and Morehead 1998, pg 316).

Learning approach and the teaching environment

The external teaching environment can influence both the type of approach adopted by the students as well as the success or otherwise of the learning approach adopted.

A factor related to the approach adopted by students is the external environment. Entwistle and Ramsden (1983, pg 21) comment that "the type of question given in a test can induce a surface approach to studying". Another related factor is the perceived level of threat. Entwistle and Ramsden (1983, pg 21) note that "students who felt the situation to be threatening, whether that was intended or not, were more likely to adopt a surface approach". In addition a heavy workload can push students towards adopting a surface

approach as they have insufficient time to master the material. Entwistle and Ramsden (1983, pg 21) quote Dahlgen: “In order to cope with overwhelming curricula, the students probably have to abandon their ambitions to understand what they read about and instead direct efforts towards passing the examinations”.

Entwistle and Ramsden (1983) note that it *is* possible for a student adopting a deep approach to fail to reach a deep level of understanding of the material for various reasons, a lack of prior knowledge, insufficient time, and so on. “A deep approach depends crucially on prerequisite skills and knowledge. If these are lacking, the student cannot carry out an intention to understand and may have to fall back to rote learning as a temporary expedient” (Entwistle in Schmeck 1988, pg 45). Entwistle (in Schmeck 1988) further discusses what qualitative research has tended to suggest regarding why a deep approach to learning is not always associated with success. “Many students who intended to understand, failed to carry through the full process necessary to achieve a deep level of understanding” (Entwistle in Schmeck 1988, pg 45). An example is when deadlines interfere with the students’ underlying intentions. “Thus a serialist strategy towards understanding will finish up as a surface approach if the later stages of integration are omitted. And a holist strategy may result in a vague, unconvincing account if insufficient time has been spent mastering the details” (Entwistle in Schmeck 1988, pg 45).

The aspects that influence a student taking a surface approach to learning are summarised well by Bowden and Marton (1998):

- Inadequate prior knowledge
- Time constraints
- An over-demanding syllabus
- Frequent assessment for credit or assessment methods that emphasise recall and thus memorisation.

These factors can also impact why a student who follows a deep approach, or who intends to follow a deep approach, does not reach a deep level of understanding of the material or does not achieve good results in the assessment.

3.3.3 The relevance of a particular discipline

Finnie (1987, pg 8) concluded his paper, "On learning styles and novice computer use", by noting that "Kolb's LSI (Learning Styles Inventory) is a general learning styles instrument and further research would be necessary to develop a specialised form for use in assessing the learning of computer skills." I do not know of any learning style instrument that has been specifically designed or modified for the computer science discipline. Following the arguments in chapter 2 that computer science is part engineering, it was decided that the model and instrument by Felder would be suitable for use in this research.

However, the ease of transfer of context is not necessarily the case from a learning approach perspective. It has been noted above that the context within which the learning takes place can affect the approach adopted. Entwistle (in Schmeck 1988, pg 48) highlights that "the precise meaning of a deep approach will have to be reinterpreted within each subject area and even within each discipline".

As the initial studies on learning approaches took place in the humanities, what researchers had to say about learning approaches in the sciences was explored. Entwistle (in Schmeck 1988, pg 48) comments that "rote learning of definitions, terms or information is a necessary part of some disciplines and may play a prominent role in the early stages of learning a new topic". This is particularly the case in "science" subjects where science students have to rely on operation learning more than "arts" students. Entwistle and Ramsden (1983) also noted that even though in science departments more emphasis is placed on knowledge of facts, this was being replaced with a focus on techniques of analysis and how to find facts rather than just the facts themselves. As summarised by Biggs (1987, pg 61) "sciences need *both* surface- and deep- related approaches; surface to focus on the fact and detail of formulae and procedures, and deep to understand them".

An important characteristic of the research undertaken by Booth (1992) was that the study sought to "uncover the specific approaches that might be present in particularly disciplinary contexts" (Marshall and Case 2003). Surface and deep approaches were identified, but with features specific to the context of programming. Four qualitatively different approaches were identified (Booth 1992). These four approaches are succinctly summarised by Marshall and Case (2003):

1. An expedient approach in which a previous program was identified which would suit the purpose of the current task;
2. A constructual approach where elements from their previously written programs were cobbled together for a solution;
3. An operation approach which focuses on what the program was going to have to do; and
4. A structural approach which focussed initially on the problem rather than the program specifications.

The first two of these approaches are considered to be surface approaches and the latter two deep approaches. Booth (1992, pg 232) comments as follows: “It is seen that the structural and the operational approaches are each in their way “deep” approaches to writing programs. They seek meaning … and they actively interpret”. “The constructual and the expedient approaches are “surface” approaches to writing programs, in that meaning is not sought but clues are being identified and exploited.”

In summary, although surface and deep approaches appear to be evident across disciplines, particular approaches may be prevalent or more relevant in particular disciplines

3.3.4 The relevance of demographics

The impact or relevance of gender, population or culture on the learning style preferences of students, or the learning approaches adopted by students, was not a focus of the research. Therefore findings from the literature reviewed on these demographic aspects are only briefly discussed below.

Learning style and demographics

Felder (2002) comments that the ILS has been translated into at least half a dozen languages. However, as noted above, the focus of the study was not on population groups and I have not reviewed any literature that analyses if different learning styles are prevalent across different cultures or populations. None of the papers reviewed, including papers where a South African sample population was used (Sayed 1988; Finnie 1987; Viljoen at al. 2001; Chen 2003) commented on the learning styles of different population groups. In the study by Van Zwanenberg et al. (2000, pg 368) there was “clearly an under-representation of most minority groups”. In 1987 Claxton and Murrell indicated

that there was a most pressing need to learn more about the learning style of minority students, in particular black students. Over 65% of the sample population in this research are black students.

Van Zwanenberg et al, (2000, pg 369) found that female and male respondents differed significantly (p=0.001) on the Visual-Verbal dimension, but not on the other three dimensions. Females appeared to be less visual and more verbal than males.

Learning approach and demographics

The applicability of learning approaches across disciplines is discussed above, in this section the applicability and relevance of learning approaches across a few demographic factors is briefly discussed.

Haggis (2003) argues that a deep learning approach is "elitist". A deep learning approach is the approach valued by academics, it is based on previous cultural assumptions and it is only attainable by a few students. Haggis (2003) also notes that in different cultures a form of memorisation (usually associated with a surface approach) led to understanding (usually associated with a deep approach). This is very important in the South African context where the demographics of students entering university have changed considerably over the past years. Students may not want to, or be able to, adopt a deep learning approach for a number of reasons including prior schooling and family experiences.

Regan and Regan (1995) report on some of the changes in university students' study process in relation to age, gender and faculty. The investigated population were first year undergraduate students at an Australian regional university. A quantitative approach was taken and the Biggs' Study Process Questionnaire was administered to the students in the first and second semester. Regan and Regan (1995) found differences in learning approaches across age, gender and faculty. One of the implications of their findings is that "it cannot be assumed that general guidelines for fostering the development of deep approaches … may be equally applicable to all subgroups of students at university in all departmental contexts" (Regan and Regan 1995, pg 28). Taking this one step further, and considering Haggis' arguments, one may query why Regan and Regan assume that the "correct" thing to do is to foster the development of deep learning approaches.

3.3.5 Learning style preferences and learning approach profiles.

The learning style preferences and learning approach profiles reported in the various studies are presented below.

Learning style preferences

Felder (1993, pg 4) notes that "the teaching style in most lecture courses tilts heavily toward the small percentage of college students who are at once intuitive, verbal, deductive, reflective and sequential". He notes that this is in part because teachers tend to favour their own learning styles and in part because they instinctively teach the way they were taught in most college classes. (Since 1993 Felder has dropped the inductive / deductive dimension.)

Felder and Spurlin (2005) summarise the learning style preferences reported in different studies. Some examples from Felder and Spurlin (2005) are provided in Table 3.1.

Table 3.1 Reported learning style preferences

Sampled Population	Active	Sensing	Visual	Sequential	N
Iowa State, Materials Eng	63%	67%	85%	58%	129
Michigan Tech, Env, Engr.	56%	63%	74%	53%	83
Ryerson Univ. Elec. Engr. 2002	63%	63%	89%	58%	132
Tulane, Engr. First-year students	56%	46%	83%	56%	192
Universities in Belo Horizonte (Brazil), science students	65%	81%	79%	67%	214
Univ. of Puerto Rico-Mayaguez Elect. & Comp. Engr	47%	61%	82%	67%	?
Univ. of Sao Paulo, Elec. Engr.	57%	68%	80%	51%	91

In Table 3.1, if 67% of students are shown as sensing learners, then by implication 33% were classified as intuitive learners.

Van Zwanenberg et al. (2000, pg 369) noted that their research indicated that "the sample were more Active, Sensing, Visual (considerably) and Sequential (just) than Reflective, Intuitive, Verbal and Global. Van Zwanenberg et al.'s (2000) findings are very similar to those presented by Felder and Spurlin (2005).

Chen (2003) investigated the preferred learning style and personality type of first, second and third year computer science students at Wits University. Kolb's learning style inventory was administered to all the students. The study followed a quantitative approach. Although the research hypothesis, that a larger portion of the third year students would have a "convergent learning style", was rejected, it was found that the majority (over 80%) of the computer science students were relatively abstract in their learning style. Although there is no direct link, Kolb's "abstract learning style" is fairly similar to the dimension referred to as "intuitive" by Felder (2004b) on the sensing / intuitive dimension. Many of the results summarised by Felder and Spurlin (2005) are inconsistent with this preference reported by Chen (2003). I am unable to account for these differences, but it does highlight the difficulty of comparing results obtained from the administration of different instruments. On another dimension, Chen (2003) found that an equal portion of the students were active as reflective. This result is in the same order of magnitude as those reported by Felder and Spurlin (2005).

Learning approach profiles

Rollnick et al. (2004; unpublished paper) describe an attempt to relate student success to their approaches to learning by constructing profiles of successful and less successful students. In the initial study (Rollnick et al. 2004) the investigated population was three groups of students at two South African Universities. In the second study two additional groups were included. A fixed response instrument that was developed in South Africa was used to measure the students' learning approaches. Although a questionnaire was administered to all the students, a qualitative approach was taken to analyse the results and profiles were drawn up for categories of students.

"A major finding was that the current students showed apparent signs of using shallower approaches than those writing selection tests, possibly because the latter wished to impress the markers of the selection test. Amongst the current students there were signs of more sophisticated approaches to learning in the more senior students, particularly in the case of the more successful students" (Rollnick et al. unpublished paper, abstract).

3.4 Additional Topics

In this section additional topics that are related to the findings of the research are briefly discussed. These topics are:

- Learning to learn and metacognition
- Study skills
- Epistemological access

As mentioned earlier, only one or two papers were consulted on each topic to provide some insight and background. The risk of this method is that different views of researchers on a particular topic are not exposed.

3.4.1 Learning to learn and metacognition

"It could be argued that the most important learning is learning to learn" (Turmo 2004, pg 229). Learning to learn involves learning to select the appropriate learning strategy for the particular situation (Turmo 2004). However, a condition precedent to this is probably the ability for the student to understand how he/she learns, that is for the student to have a fair level of metacognitive development.

Case and Gunstone (2002, pg 461) quote Gunstone where he "stresses that all learners are metacognitive and that the associated pedagogical goal should be to *enhance* metacognition." An article by Case and Gunstone (2002) that linked metacognitive development with a shift in approach to learning was selected as an appropriate paper to review for a number of reasons: the link with learning approaches; the context is Engineering and as noted in Chapter 2 Computer Science is part Engineering; and the sample population is South African.

Case and Gunstone (2002, pg 461) note that one of the first descriptions of metacognition comes from Flavell who described metacognition as "one's own knowledge concerning one's own cognitive processes and products or anything related to them". Case and Gunstone (2002, pg 461) also provide the following succinct definition from Baird, "metacognition refers to the knowledge, awareness and control of one's own learning". Baird quoted by Case and Gunstone (2002, pg 469) argues that metacognitive development is "demonstrated by a shift in a student's approach to learning".

Case et al. (2001) identified four major categories representing metacognitive development. These were: 1. Knowledge and awareness (conception of learning); 2a. Control: Organising one's learning; 2b. Control: Monitoring of learning; 3. Preparing for learning beyond the subject.

Case and Gunstone (2002) argue that metacognitive development is demonstrated by a shift in a student's approach to learning. Through their research they found that students who had adopted a conceptual (deep) approach from the start of the course, consolidated their use of this approach as the course progressed. Some of the students who had adopted predominately an algorithmic approach managed to shift, in various degrees, to using a conceptual approach. Those students who started off using an information-based approach did not manage any noticeable metacognitive development.

Case and Gunstone (2002) and Case et al. (2001) highlight some aspects of an innovative second year chemical engineering course that might have promoted the metacognitive development experienced by some of the students. These are summarised below:

- "Cover Less, Uncover More." The amount of material in the curriculum was reduced. This was achieved through involving all relevant teaching staff in a workshop to decide on what content had to be retained in the curriculum.
- Sufficient time available in class for discussing and doing problems[1].
- The use of journals. "Journals were used for two purposes: to prompt students to reflect on their learning, and to promote conceptual understanding" (Case et al. 2001, pg 318).
- An unlimited time test. One test was given where the students had approximately 6 hours to complete a 2-hour test. Often students believe they need to work faster in tests to do well. In this situation the students learnt that they needed to focus on other aspects, such as understanding the material.
- Students were allowed to bring a "crib sheet" into all tests and examinations. This was to de-emphasise memorisation. This "crib sheet" was one A4 sheet. It appears that the "crib sheet" reduced stress for some students and it was also an important learning experience.
- Assessment questions that focused on assessing conceptual understanding rather than solving numerical problems. Case et al. (2001) suggest adding questions

[1] The term "problem" is used to refer to any exercise in class, at home, or in a test, which requires students to provide an answer. The term is standardly used to describe questions involving a numerical exercise, but questions requiring a qualitative explanation are also included.

like “Explain why …”, “What if …”on to standard numerical problems. I am not sure if this would have the desired effect in the FAC course as English is not the first language for the majority of the students, and therefore instead of assessing conceptual understanding, agility with the English language may be assessed instead. Case et al. (2001) also suggest altering multi-step numerical problems so that students had to explain what they would do, rather than performing the actual calculations. When considering the different learning styles of students it is evident that this approach may not suit global learners who make intuitive leaps and may be unable to explain how they came up with solutions.

Case and Gunstone (2002) also highlight some aspects of the course that may have been detrimental to metacognitive development:

- Heavy out of class workload: Case and Gunstone (2002) argue that hand-in load should be reduced and that a co-ordinated effort to teaching and learning across various courses is required. If this is not done, the students use the time made available by one lecturer for the students to focus on obtaining a deep understanding of the material, to do the tasks required for another course.
- Time pressure in assessments encourages students to find ways to work faster rather than to focus on understanding the work.

The papers reviewed above provide some insights and ideas for the FAC lecturer to reflect on when considering how to improve the success rate of the FAC course. Case and Gunstone (2002, pg 469) stress that it is a “challenging task to create a teaching environment that fully supports the development and use of conceptual (deep) approaches, and that lecturers may need to rethink certain taken-for-granted aspects of typical tertiary science and engineering courses if they wish to achieve this aim”. In addition lecturers may want to consider Haggis’ concern that goals and values of a deep approach are not relevant for mass higher education.

In the words of Turmo (2004) “The successful learner has learned how to learn” and in my opinion the successful lecturer has learned how to develop the use of appropriate learning approaches in his students. An appropriate learning approach may not be a deep approach to learning; it may be more aligned with a strategic approach. Following on from this, in the next section, some literature on how to teach study skills is reviewed.

3.4.2 Study skills

In the previous section some of the environmental aspects that promote metacognition and the adoption of a deep learning approach were highlighted. In this section I expand on that topic by very briefly commenting on some literature regarding the teaching of study skills and learning strategies as well as metacognitive development. Although I have used the term “study skills”, it is too “shallow” a concept and does not cover the entire essence of what students need to gain knowledge in. A better term may be “academic competence”, where what I am referring to is the explicit exposition of the mores and traditions of the discipline. The students need to be learn, and be taught, what study approaches to use when, and how to tackle the various components of the course.

Case and Gunstone (2002) argue that the promotion of metacognitive development should be integrated with the content matter that students are studying. The view is that students are not able to transfer the proficiency from one context to another. This view is supported by McCune and Entwistle (2000) who comment that “effective advice should ideally take into account the more idiosyncratic and dynamic aspects of studying, and the specific academic discourse and learning contexts within which the students are operating” (McCune and Entwistle 2000 pg 15). Rollnick (2005) reports that Treisman emphasises the importance of making the programme part of the academic enterprise, rather than isolating it in a remote building, taught by staff unrelated to the department. This issue goes to the heart of epistemological access, discussed in the next section, that students need to become part of the community of practice.

I have not reviewed any literature on the alternate approach of teaching study skills as a separate entity and so am unable to compare the above recommendations with alternatives.

3.4.3 Epistemological access

Morrow (1994) coined the term “epistemological access”. Learning how to become a participant in an academic practice can be described as gaining access to the practice in question. Morrow (1994) highlights that epistemological access can only be acquired in practice through the joint efforts of the learner and the teacher. There are many things that may help a student to gain epistemological access, for example access to good textbooks, the company of other serious learners, the sympathetic assistance of teachers (Morrow 1994). Treisman (referred to by Rollnick 2005) notes that students who study in groups

not only share knowledge about the topic, but also about their understanding of what is required of them by their lecturers and the university.

Rollnick (2005) highlights that learning how to function in the university environment involves learning holistically about life at the university and not just about knowledge acquired in courses. Haggis (2003) notes that provision of such access requires academics to be explicit with regard to the literacy norms of specific subjects, noting that in some quarters this is viewed as “spoonfeeding”. Without these new forms of expression being modelled and explored, students may never access the ways of a particular course or the university culture.

Prior computer exposure and experience could potentially assist a student to gain access to the practices of the FAC course.

3.5 Conclusion

In this chapter the literature that informed the study has been critically reviewed. A description and discussion of the two key theoretical frameworks: learning styles and learning approaches were the foundation of the chapter. This was followed by a review of some of the relevant literature that made reference to or applied these theoretical models. Finally, three additional topics that are related to the findings of the research were briefly discussed. In the next chapter, the selected methodology, founded on the literature reviewed, will be described and discussed.

4. METHODOLOGY

4.1 Introduction

The problem to be investigated was described in some detail in chapter 1. The aim is to understand the learning styles and approaches of students who are studying the FAC course at Wits. After reviewing the literature, it became evident that a mixture of quantitative and qualitative data would be the most appropriate. This chapter therefore briefly outlines the advantages and disadvantages of qualitative and quantitative research, the research design and methodology followed as well as the instruments selected. Both a survey and ethnographic design were chosen and both quantitative and qualitative instruments such as questionnaires and interviews were used. An overview of how the study was conducted including the sample design and sample profile is presented. The process used to capture and edit the data is described in this chapter, but the procedures used for data analysis are described in chapters 5 to 7.

4.2 Qualitative and Quantitative Research Approaches

In educational research, the terms "qualitative" and "quantitative" are used in a number of contexts. These terms are often used to describe the approach to the study, the type of data collected and the instruments used. Tesch (1990, pg 43) comments that often "qualitative research is meant to denote all research **not** concerned with variables and their measurement". Tesch (1990, pg 55) also comments that "strictly speaking there is no such thing as qualitative research. There are only qualitative data". The terms "qualitative" and "quantitative" are also used to describe a paradigm, a way of "tackling" the research and viewing the "truth". In my view I have predominately followed a qualitative paradigm, as I do not want to focus on numbers and their measurement, but on a description of the learning styles and approaches adopted by the students.

Although there are various approaches and methods used when doing qualitative research, there are a number of similarities that could be referred to as the characteristics and benefits of qualitative research. These characteristics, which are summarized below, are the reasons that a predominately qualitative approach was selected.

- **Descriptive data:** Qualitative research is descriptive rather than numerical. As summarised by both Fraenkel and Wallen (1990) and Schumacher and McMillan

(1993): “Qualitative data are collected in the form of words or pictures rather than numbers”. The aim is to capture the richness and complexity of a situation.

- **Discovery:** The aim of qualitative research is discovery that leads to new insights rather than verification of an idea. I was looking to discover if there are any relationships between particular learning styles and approaches and the performance of the students. I was not trying to verify any particular relationships.
- **Participant's Perspective:** Qualitative researchers want those who are studied to “speak for themselves”. Researchers adopting a qualitative perspective are concerned with understanding the perceptions of individuals or groups (Bell 1993). Individual quotes from students are provided in chapter 7.
- **Holistic approach:** The aim of qualitative research is to understand the entire unified experience and not separate variables.

Although qualitative research has its benefits, it is important to be conscious of the disadvantages and limitations of a qualitative approach, these are summarised below:

- **Limited generalisability:** Due to the narrow scope of most qualitative research, the results can seldom be generalised. In qualitative research the focus is rather on transferability (Lincoln and Guba 1985). Therefore the research should be described and documented in such a way as to enable others of similar circumstance to recognize problems and ways of solving similar problems in their own group. I have paid particular attention to this and have attempted to describe the method used in detail as well as the results obtained.
- **Dependent on researcher's observations:** Although a researcher will try to be objective and impartial there is always some degree of subjectivity and bias as each researcher has a unique background and way of perceiving things. Video and audio tapes can reduce this problem by providing a means of reviewing the setting and getting the views of other professionals (Fraenkel and Wallen 1990). In addition, when interpreting the data a qualitative researcher will judge and appraise the meanings and relationships and give a reasoned judgment according to some external criteria or theoretical framework. Two theoretical frameworks, those of learning styles and learning approaches, were used to interpret the significance and value of the phenomena observed.

Schumacher and McMillan (1993) comment that many of the features of qualitative and quantitative research are not absolute and a mixture of the two approaches is often appropriate. The purpose of my research is to *understand* the learning styles and approaches of students studying the FAC course. This can be done by following a quantitative approach and looking for relationships between learning styles and approaches and factors such as performance on examinations and demographics. This approach is valuable as it provides a good, objective, overview of the phenomenon. This is the primary approach that has been taken to analyse the results from the questionnaire. However, as discussed above, I wished to also intimately understand the learning style and approach adopted from the students' perspectives. A qualitative approach was more suitable for this and I therefore interviewed a number of students and analysed the data using qualitative methods.

In summary, I have used predominately a qualitative approach, but for additional insight and to mitigate some of the limitations of a qualitative approach, elements of a quantitative approach have also been used. This decision is supported by the literature reviewed. When referring to research into understanding student learning, Entwistle and Ramsden (1983, pgs 6 & 28) refer to the "importance of trying to **marry qualitative and quantitative methods** of research" and to their main concern "to use both quantitative and qualitative methods for collecting and analysing data". They note that qualitative methods such as semi-structured interviews are one of the hallmarks for understanding student learning, but that more traditional quantitative techniques can be incorporated and can enrich the understanding. In the next section the research design selected is described.

4.3 Overall Research Design

The research study was primarily exploratory in nature as a result of the research questions I was attempting to answer. According to Mouton (2001) there are a number of research designs that could be selected for questions of an exploratory nature. From a quantitative perspective, a survey is an appropriate design to get a broad overview of a large sample. From a qualitative perspective, an ethnographic design is appropriate to provide an in-depth description of a group of people. Both of these designs, which complement each other, were used and are described below.

Neumann (1997) describes a survey as a process in which the researcher translates a research problem into questionnaires. These questionnaires are then administered to a sample group. The quantitative data collected is used to describe certain characteristics of the sample group at a particular point in time. In this study, a survey was used in order to gather information about the learning style, learning approach, demographics and computer background of the students studying the FAC course. A benefit of a survey is the ability to gather information from a large number of people in a short period of time. This was the primary reason for selecting a survey in order to get an overview of the relevant characteristics of the students studying the FAC course.

According to Mouton (2001), one of the limitations of a survey is a lack of depth and insider perspectives, which can lead to the criticism of "surface level" analyses. A particular strength of the second design selected, an ethnographic design, is that it provides in-depth insights.

The goal of ethnography is to paint as vivid and accurate a picture as possible so that others can understand the nuances of the particular situation. According to Fraenkel and Wallen (1990, pg 375) ethnographic research is always carried out in the natural setting as the aim is to understand, document, and portray the "everyday experiences of individuals". In this study the setting was not natural as instead of observing students, I used semi-structured interviewing and interviewed eight students to find out how they approached their studies. This could be viewed as a weakness of the study. However, Mouton (2001) notes that semi-structured interviews are appropriate instruments for ethnographic research.

Both of these designs, survey and ethnographic, were used and both quantitative and qualitative instruments such as questionnaires and interviews were used for data collection. These instruments are discussed in the following sections.

4.4 Research Instruments

As this was an initial exploratory study, and for triangulation to check on data reliability and validity, two types of instruments were used: a questionnaire with structured, predominately closed questions to obtain a broad overview of a large sample, and an interview with open-ended questions to provide an in-depth understanding from a small

sample of students. These two instruments and why they were selected are discussed in some detail below. The structure used to discuss the two instruments is similar:

- Rationale for the instrument including the advantages and disadvantages;
- Design of the instrument;
- Preparation for administration of the instrument;
- The sample design and sample profile;
- Data collection;
- Data capture;
- Data cleansing and normalisation.

The questionnaire is discussed in section 4.5 and the interview in section 4.6

4.5 The Questionnaire

4.5.1 Rationale for the questionnaire

Several authors (Fraenkel and Wallen, 1990; Cohen and Manion, 1982; Mouton 2001) agree that the instruments typically used in surveys are questionnaires and structured interview schedules. There are many advantages of questionnaires and according to Schumacher and McMillan (1993, pg 238) the "questionnaire is the most widely used technique for obtaining information from subjects". Sanders (1995, pg 713) highlights some of the advantages of questionnaires, in particular that "they allow for easy data collection from very large samples". This is the primary reason a questionnaire, rather than a structured interview, was selected for the survey. In an economical manner, the questionnaire enabled many of the students registered for the FAC course in 2004 to be reached. Administering the questionnaire to a relatively large sample of students enabled the different learning styles and approaches of different groups of students, for example those who are excelling in the course, those who are struggling, and so on to be researched.

Although questionnaires are widely used and have a number of positive attributes, they have limitations and disadvantages that must be taken into account. Sanders (1995) notes that one of the main disadvantages of questionnaires, compared to interviews, is that the researcher cannot easily clarify unclear or ambiguous questions. This is usually the

situation as the questionnaires are often posted to the respondents and therefore the researcher is not present. To reduce this risk I administered the questionnaire personally. However, with over 100 respondents it was not really practical for respondents to easily seek clarity.

As the respondents cannot easily seek clarity, Sanders (1995, pg 713) stresses that "it is essential that the questions are clearly and unambiguously worded". However, as highlighted by many authors, it is difficult to design a good questionnaire. Schumacher and McMillan (1993, pg 239) note that "researchers should give much thought to justification whenever they develop new questionnaires" and they recommend that "in many cases existing instruments could be used or adapted for use instead of preparing a new one". I took this approach and used a combination of existing questionnaires. A further way to improve the quality of a questionnaire is extensive piloting. The pilot study is discussed in section 4.5.3 below.

An additional major problem with questionnaires is the poor return rate. Sanders (1995, pg 714) notes that "this is often experienced when postal questionnaires are used". A poor return rate may cause bias in the research data, as respondents with certain characteristics may not respond. To mitigate against this risk I administered the questionnaire after one of the FAC course lecture periods. This is discussed in section 4.5.5 below.

To reduce some of the disadvantages of questionnaires, it is important that sufficient attention is paid to the design and format of the questionnaire. This is discussed in the next section.

4.5.2 Design and format of the questionnaire

The questionnaire used in this study has four parts:

- Part A – Demographics;
- Part B – Computer background;
- Part C – Index of learning styles;
- Part D – Study approaches.

I have collectively referred to these four parts as the "questionnaire". A sample questionnaire is attached as Appendix D.

The purpose of part A was to collect biographical data such as age, gender and home language. Writers such as Biggs (1987) highlight the importance of values and attitudes derived from the students' home backgrounds on the students' approach to learning. Part A was very short and comprised of eleven simple questions on one page. The students were told that answering all the demographic questions would be useful, but if they were uncomfortable about any question in part A they did not need to answer it. A number of students did not provide their age and the occupation of their parents.

Part B was also very short. It had five questions related to the respondents' computer exposure and eleven questions related to the respondents' reason for studying Computer Science. The answer for each question was either "Yes" or "No" which the respondent could select by putting a tick (√) in the box that corresponded with their answer.

Although I have collectively referred to the four parts as a questionnaire, the correct term for Part C and Part D are diagnostic tests. Schumacher and McMillan (1993) note that the term "tests" refers to the use of test scores as data. Schumacher and McMillan (1993, pg 42) further expand that "a numerical value is obtained as a result of each subject's answer to a standard set of questions. The instrument is used as a way to describe or measure a characteristic of the subject".

Part C is an existing diagnostic test for learning styles. The Index of Learning Styles (ILS) is an instrument to assess the preferences of the respondents for the categories of the Felder-Silverman Learning Style Model. The selection and scoring of the ILS are discussed in section 4.5.2.1 below.

Part D is an existing diagnostic test for assessing the learning approach of the respondents. The selection of the instrument and the amendments made to it are discussed in section 4.5.2.2 below.

I adhered to the following design guidelines and advice when I compiled the questionnaire:

- **Colour coded:** Due to the length of the questionnaire I colour coded the different parts of the questionnaire to both assist with the identification of the parts of the

questionnaire and to make the questionnaire interesting and attractive for the respondents (Sanders 1995)

- **Neat, attractive layout:** To ease the task of responding, the questionnaire was professionally printed and easy to read (Neumann 1997).
- **Questions worded clearly:** To minimise ambiguous questions and responses, in parts A and B the questions were worded clearly. Jargon, slang and abbreviations were avoided (Neumann 1997). Simple and direct language was used (Oppenheim 1996).

4.5.2.1 Learning style instrument

Using the phrase "Learning Styles" in an Internet search, over 2 million hits were obtained. This gives an indication of both the popularity of the concept as well as the amount of available literature. Narrowing the search to "Learning Style Instruments" nearly half a million hits were obtained. It is obvious that there is a vast amount of literature on learning styles. In 1995 Felder noted that there were over 30 learning style assessment instruments that had been developed in the past three decades. Almost 10 years later, this gives an indication of the large number of instruments available to assess learning styles. Some of the better-known ones include Kolb's Learning Styles Inventory (Kolb 1985), Myers-Briggs Type Indicator (MBTI), the Gregorc Style Delineator (Gregorc 2004b) and Felder-Silverman's Index of Learning Styles (Felder and Silverman 1988). Viljoen et al (2001) have developed a normative learning style instrument using South African subjects. However, the objective of the research project was not to comprehensively review this literature and the associated instruments, but to select an appropriate instrument that will assist with the answering of the research questions. For the reasons outlined below, I believe the Felder-Silverman Learning Style Model is an appropriate model, and the associated Index of Learning Styles (ILS) is an appropriate instrument. I therefore used the ILS to assess the preferences of the students for the categories of the model.

- **Existing model and instrument:** Firstly, I have chosen to use an existing model and instrument and not design my own model. Existing models and instruments have been trialled and piloted and are therefore more robust than if I was to design my own model and instrument.

- **Meets research aims:** Felder's "primary interest in learning styles is their usefulness for instructional design" (Richard Felder, personal communication, 19 March 2004). The aim of my research project is not to use the ILS as a predictor of academic performance, but to use it to better understand the learning style of FAC students so that the FAC lecturer can meet the needs of all his students, particularly those who are failing the course. My aims and the aims of the ILS are aligned.
- **Comprehensive:** The ILS covers all of the most important variables affecting learning that are under the lecturer's control. None of the existing models covered all of these variables when Felder and Silverman designed their model. The ILS is a composite model which, in some cases, takes dimensions directly from other models, for example: sensing/intuition from the MBTI; active/reflective from Kolb; sequential/global from a number of models. (Richard Felder, personal communication, 19 March 2004). The ILS has four dimensions, a model such as Kolb's only has 2 dimensions / scales.
- **Reliability:** Van Zwanenberg et al. (2000) explored the internal reliability of the ILS and reported that the low internal reliability statistics for the ILS prompted some caution for the use of the ILS. In this regard, the statement by Felder and Spurlin (2005) given at the end of this section is very important. In a later study by Zywno (2003) it was reported that the internal consistency reliability was good: "Cronbach alpha coefficients met acceptable limits and correlational and factor analysis suggested that the model scales (dimensions) assess separate qualities, as theoretically predicted" (Zywno 2003, pg 12). In addition, "test-retest analysis of the ILS scores suggested a strong to moderate reliability of all scales (dimensions)" (Zywno 2003, pg 12).
- **Validity:** Zywno (2003) found that convergent construct validity and discriminant construct validity were supported by the ILS. The instrument scores are said to have convergent construct validity if they correlate with quantities with which they should correlate. The instrument scores are said to have discriminant construct validity if they fail to correlate with quantities with which there is no reason to expect correlation (Felder and Spurlin 2005).
- **Science discipline:** The ILS has been designed for the engineering discipline, but is also suitable for science disciplines. Felder (1993, pg 1) notes that "Felder and Silverman have synthesized findings from a number of studies to formulate a learning style model with dimensions that should be particularly relevant to science

education". The ILS has been used by researchers in the computer science discipline, in particular Chamillard and Karolick (1999) and Thomas et al. (2002).

- **University Students:** The ILS was designed for university students. In contrast, the instrument designed by Viljoen et al. (2001) was designed for individuals in a business environment; Honey and Mumford's (1982) styles of learning were designed for managers; Gregorc's (2004a) model and instrument are for adults only; and Wyman's (2004) model and instrument are for school children.
- **Culture:** Unlike the model by Viljoen et al. (2001), the ILS was not specifically designed for the South African culture. However, Felder has visited South Africa three times and has an understanding of some of the issues faced in South Africa. The ILS has been translated into a number of languages and is in use across a number of cultures (Felder 2004b).
- **Language Understandable:** The language used in the ILS is clear. It has been noted that students have had difficulty understanding the language used in some of the other instruments, for example Kolb (Zywno 2003). However, due to differences between the American and South African culture, the questionnaire was piloted to make sure that students comparable to the research sample understood the language used.
- **Instructions Clear:** Students have to choose from two options for each question – there is no ambiguity of what needs to be done. In contrast, Zywno (2002) found that when completing the Kolb instrument, some students chose one word instead of ranking the words, implying that some students were having trouble understanding the instrument.
- **Short:** The ILS has 44 questions, with each having 2 options. Although there are shorter instruments, it was confirmed in the pilot study that the ILS would only take approximately 10 minutes for the students to complete.
- **No Cost:** "The ILS is available at no cost to students and faculty at educational institutions to use for non-commercial purposes" (Felder 2004b). In contrast there is a fee to use some of the other instruments.

For language reasons, the wording of two of the questions were amended slightly. In the ILS question 2 reads as follows:

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

This was altered to read as:

2. I am more likely to be considered
a) realistic.
b) innovative.

Likewise in the ILS questions 34 reads as follows:

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

This was altered to read as:

34. I am more likely to be considered
a) sensible.
b) imaginative.

The phrase "I am more likely to be considered" was selected as the replacement phase as it is used elsewhere in the ILS, for example question 22.

Felder and Spurlin (2005) highlight some important aspects that must be taken into account when using the ILS. These aspects are summarised below, but the detail is available in Felder and Spurlin (2005).

- **Learning style dimensions are continua, not either-or categories.** A student's preference may be mild, moderate or strong. When I carried out my initial analysis of the results I used nominal values, that is a student was either visual, or verbal etc. In hindsight this methodology may not have been absolutely correct. However, many researchers, including research reported on by Felder and Spurlin (2005), have followed this method and I have reported these results as well as the results when values on an interval scale were used, that is when a score on a continuum was calculated.
- Learning style profiles **suggest behavioural tendencies** rather than being infallible predictors of behaviour.
- Learning style preferences **are not reliable indicators of learning strengths and weaknesses.** The score is a measure of a preference, and not of a skill, in one of the categories of a dimension.

Finally, the following advice from Felder and Spurlin (2005) must be taken into account when using the ILS:

> "As long as the Index of Learning Styles is used to help instructors achieve a balanced course and to help students understand their learning strengths and areas of improvement (as opposed to being used to predict students' grades or dictate their course and curriculum choices), our analysis and the other published analyses suggest that the current version of the instrument may be considered reliable, valid and suitable".

4.5.2.2 Learning approach instrument

According to Ramsden (1992) the two best-known questionnaires which investigate students' learning approaches are the Study Process Questionnaire (SPQ) designed by Biggs and the Lancaster Approaches to Studying Questionnaire (LASQ) designed by Entwistle et al. There are a number of different versions of the LASQ, for example ASI (Approaches to Studying Inventory) and ASSIST (Approaches and Study Skills Inventory for Students) available from the University of Edinburgh (2004). The Biggs and Entwistle et al. questionnaires have similarities: many of the questions were derived from interviews with students; a Likert-type scale is used and students are asked to agree or disagree with questions posed. Based on the problems with Likert-type questionnaires highlighted by Haggis (2003), Marshall and Case (2003) and Bennett et al (2001), for example that the intervals between coded items of a Likert-type scale are not equal and therefore the actual scores are not relevant, the decision was made to use a Fixed Response instrument such as the one recommended by Oppenheim (1996) and used by Bennett et al. (2001) and Rollnick et al. (2004).

A diagnostic test that was constructed by Rollnick et al. (2004) in South Africa with Chemistry students was used. This diagnostic test enabled profiles of students employing deep and surface approaches to be constructed. The benefits of using this existing instrument is that it has been designed and piloted in South Africa and students should be comfortable with the available responses as they are written in the language of South African first year students. The instrument was modified slightly to refer appropriately to the FAC course.

Three questions that were not relevant to the FAC course were removed and were replaced with three questions that are pertinent for the FAC course. For these questions the method described by Bennett et al. (2001) and Rollnick et al. (2004) that is aligned with recommendations of Oppenheim (1996) to follow a two-step approach was

followed. In the pilot study, with second year computer science students, three FAC specific questions with open-ended responses were included in the Learning Approach instrument. For each of the three questions, the responses received were clustered to form possible answers (Oppenheim 1996). For each cluster of answers, I summarised the answers into one summary response. These three FAC specific questions with the possible responses were then included in the questionnaire administered to the sample group. As with the other questions in the instrument, the students were also given the option of providing their own response. Ideally the three new questions should have been re-piloted with the multiple-choice answers, but time did not permit this. Instead the multiple-choice answers were reviewed by peers.

Although I have elected to use the instrument designed by Rollnick et al. (2004). I am aware of some of the limitations of this decision. For example the questionnaire was designed for Chemistry students and Haggis (2003) and Marshall and Case (2003) highlight some problems when approaches to learning are taken out of the contexts in which they were formulated. I did try and recognise the differences in context by modifying some questions to refer to "FAC tut/lab sessions" rather than "essays or projects".

In addition to designing the questionnaire, other preparation for the administration of the questionnaire was required. These aspects are discussed below.

4.5.3 Preparation

The following items were attended to prior to the administration of the questionnaire:

- **Ethical approval:** Approval for the research project, the questionnaire, cover letter, consent form and the interview schedule was obtained from the Computer Science Ethics Committee.
- **Cover letter:** A cover letter was attached to the questionnaire. This letter explained the reason for the study and advised the students that their participation was completely voluntary. The confidentiality of the students' responses was also guaranteed and the use of the information was explained. A copy of the cover letter is attached as Appendix B.
- **Consent form:** A consent form was attached to the questionnaire. Each student was asked to sign the consent form indicating that they had read and understood the

research project information sheet and that they were willing to participate in this study. A copy of the consent form is attached as Appendix C.

- **Pilot:** The importance of piloting the questionnaire was noted in section 4.5.1. The questionnaire was piloted with twenty second year computer science students. A copy of the spoken instructions for the pilot group is attached as Appendix E. Following the pilot, a few small amendments were made to the cover letter, spoken instructions, Part A of the questionnaire as well as the changes to Part D, the learning approach instrument, discussed below. From the pilot it was determined that the questionnaire would take a maximum of 30 minutes to complete with most students completing it in under twenty minutes.

Before describing the administration of the questionnaire and the data capture, the sample design and sample profile is described in the next section.

4.5.4 Research sample

The target population was FAC students within the School of Computer Science at Wits. The intended sample was the 166 students registered for the FAC course in 2004. The sampling method used is often referred to as convenience or availability sampling (Schumacher and McMillan 1993; Vlaardingerbroek and Ros 1990). Convenience sampling "involves using whatever subjects are available to the researcher" (Schumacher and McMillan 1993, pg 160). According to Schumacher and McMillan (1993) this form of sampling is the most common type in educational research. The convenience sample was the 113 students who attended the FAC lecture on 11 May 2004 and answered the questionnaire. The sample size was reduced from 113 students to 99 students once the thirteen Higher Diploma (HDIP) students and the one student who did not provide a student number were removed from the sample. The reason for removing these students is provided in section 4.5.7

A limitation of convenience sampling is that the sample may be biased. To assess the extent of the bias the attributes of the students in the FAC 2004 class were compared to the attributes of the sample. Two primary aspects were considered:

- The final marks of the students in the FAC 2004 class and the sample;
- The demographics of the students in the FAC 2004 class and the sample.

Exam marks

Although 166 students were initially registered for the FAC course in 2004, 161 students wrote the final FAC exam in June 2004.

In order to compare the marks of students in the FAC 2004 class with the marks of the students in the sample, the percentage of students achieving various grades was investigated. This is shown in Table 4.1 below.

Table 4.1. A comparison of the marks of students in the FAC 2004 class and the convenience sample

Attribute	**FAC 2004 Class (161 students)**	**Convenience Sample (99 students)**
Course Average	49%	52%
	Percentage of class	**Percentage of sample**
Fail: below 40%	22%	17%
Fail (40% - 49%)	28%	26%
Third (50% - 59%)	26%	25%
Second (60% - 69%)	18%	22%
Upper Second (70%-74%)	4%	6%
First (75% - 100%)	2%	3%

It is evident from Table 4.1 that the convenience sample is biased towards students who obtained higher marks for the FAC course than the entire class. The average year mark for the sample is 52%, whereas it is 49% for the FAC 2004 class. On a percentage basis more of the sample students passed the course, 56%, than the FAC class at 50%. Instinctively, these differences between the class and the sample are correct as the sample excluded the students who did not attend the lecture and common sense dictates that these students are more likely to fail the course. Even though these differences exist, it was felt that the sample was sufficiently representative of the FAC 2004 class to continue with the analysis of the results.

Demographics

Secondly the demographics of the FAC 2004 class were compared with the demographics of the sample. The demographics of the FAC 2004 class were obtained from the University of the Witwatersrand Academic Information Systems Unit. Data for 146 of the 161 students were obtained. This was taken as a true reflection of the FAC 2004 class.

Table 4.2 Demographics of the FAC 2004 class and the convenience sample.

Attribute	**FAC 2004 Class (146 students)**	**Convenience Sample (99 students)**
Age	20	20
	Percentage of class	**Percentage of sample**
Gender: Female	14.38%	14.14%
Home language – English	34.25%	32.32%
Population Group: Black	64.38%	65.66%
White	21.92%	20.20%
Indian	11.64%	12.12%
Coloured	2.05%	2.02%

It is evident from Table 4.2 that the demographics of the FAC 2004 class and the convenience sample are very similar in nature. The class is predominately young, black males. There are only 21 females in the class (14 black, 3 white, 3 Indian and 1 coloured). The average age of the class is 20, (one student is 16 years, one student is 27 years and the majority of the students are 19 years old).

In summary, some of the attributes of the sample have been compared to some of the attributes of the students in the FAC 2004 class. Based on a comparison of these attributes the sample data can be used as a fair representation of the FAC 2004 class. However, it must be noted that the attributes of the sample data have not been compared to the attributes of students registered for the FAC course over a number of years. Therefore the generalisation of the results to FAC students in previous or subsequent enrolment years is limited.

Before describing the detail of the data collection and data capture, some additional background information on the sample population is provided.

Background information

In order to be accepted into Computer Science, the students have to have achieved good mathematics marks (a C which equates to above 60%) on the higher grade in their final year of school (their matric year). On average the students in the FAC class obtained over 68% for matric mathematics. The average matric mathematics mark for black students was 65.89%. Whereas the average matric mathematics marks for non-black students was 77.8%. There is a moderate positive correlation between matric mathematics marks and FAC course marks ($r = 0.36$).

The average class mark for the FAC course was 52% and the average FAC course mark was 49%. The class mark comprises the results from three class tests. The final course mark equates to 40% from the class mark and 60% from the exam mark. There is a statistically significant difference between the average FAC course mark for black students (46.6%) and the average FAC course mark for non-black students (63.2%), (p=0.00). A large percentage of the class (50%) failed the FAC course in 2004. Only 38% of the black students passed the FAC course whereas 91% of the non-black students passed the FAC course. Although only 14% of the sample was female, no correlation was found between gender and FAC course mark.

Computer Exposure

Part B of the questionnaire had five questions related to the respondents' prior computer exposure and eleven questions related to the respondents' reason for studying Computer Science. Of the eleven questions related to the respondents' reason for studying computer science, three of the questions related to the students' desire to learn about the operational use of a computer, for example how to use a computer, word processing package and spreadsheets. As this was not the focus of the study a very simple method was used to analyse this data. If a student replied "yes" to a question, a value of "1" was assigned to the response and a value of "0" for a "no" response. Two scores for each student were calculated: the sum for prior computer exposure and the sum for their desire to learn about the operational use of a computer. Some relationships were then examined.

There is a positive correlation between prior computer exposure and FAC course mark (r = 0.38). That is, there is some indication that students who had exposure to computers prior to coming to university achieved better grades for the FAC course than those who did not. There is a statistically significant difference between the computer exposure score for black students (1.37) and the computer exposure score of white students (3.56), (p=0.00). White students have greater prior computer exposure than black students.

There is a statistically significant difference between the desire of black students to learn about the operational use of a computer (1.8) and the desire of white students to learn about the operational use of a computer (0.5), (p=0.00). That is black students have a greater desire to learn about the operational use of a computer than white students. This could be because black students have not had the opportunity to learn about word processing packages and spreadsheets prior to coming to University.

In the next sections the collection and capture of the data is described.

4.5.5 Data collection

As previously noted, a problem with questionnaires is a poor return rate. To reduce this risk, various options for administering the questionnaire to the available sample were considered. Due to the traditionally poor rate of return from postal surveys this option was not considered. One option that was considered was the use of an electronic survey. With this approach, the students would be able to access the questionnaire via a computer and enter their answers electronically. The advantage of this approach was that the data would be captured by the students, thus saving time and errors. This approach was not followed as it was felt that there was a high risk of not getting a good return.

To maximise the return rate, it was decided that it was best to administer the questionnaire after a lecture period. Using tutorial time, rather than a lecture period, was considered, but the students attend tutorials at different times and there was a small risk that students would discuss the questionnaire introducing bias.

The best time to administer the questionnaire was discussed with the FAC course lecturer. It was decided to administer the questionnaire on a Tuesday when the students had two computer science lectures one after the other, with a fifteen minute break in between the two lectures. The FAC course lecturer kindly agreed that the last fifteen minutes of a lecture period could be used and the students were asked to give up their break. The date selected was 11 May 2004. This was during the second term of the year and meant that students had been studying FAC for eleven weeks. The entire FAC course is given over fourteen weeks.

I handed out the questionnaire to all the students present at the lecture. I thanked the students for their time and advised them that their participation was voluntary and that the information provided by them would be kept confidential. I then went through the instructions for answering the questionnaire. A copy of the spoken instructions is attached as Appendix F. I was present whilst the students completed the questionnaire. Very few questions were asked by the students. The few questions that were asked related to part A of the questionnaire where students asked if they could omit a question.

The next step was to capture the responses to the questionnaire. The procedures used to capture and edit the data as well as to minimise data capture errors are described in the next section.

4.5.6 Data capture

To capture the responses to the questionnaire, an Excel worksheet was developed with a number of sheets. Five sheets were developed:

1. Consent form
2. Demographics
3. Computer Background
4. Learning Style
5. Learning Approaches

For part A and part B of the questionnaire a number of questions were closed. For all the closed questions I captured the possible answers into the worksheet. The features of the worksheet then ensured that these answers were always spelt in exactly the same manner thus reducing the possibility for errors. For a number of open questions, common answers were identified. In this case, to assist with data capture and minimise capturing errors, possible answers for these open-ended questions were entered into the worksheet. The features of the spreadsheet meant that as an answer to a particular question was entered, the tool would suggest a response. This minimised the same response being entered with a number of different spellings.

After all the data was captured, a number of questionnaires were randomly selected and the responses on the questionnaire were checked against the response captured. No errors were detected. In addition, the capturing sheets for ILS and the study approaches questionnaire were designed to highlight any obvious data capture errors. For example, in the sheet used to capture the responses to the learning approach test, if a response was entered that was outside the possible range a “#N/A” was automatically inserted into a corresponding cell. The steps taken to clean the data are discussed in the next section.

4.5.7 Data cleansing and normalisation

Prior to analysing the data, the data needed to be cleaned, normalised and merged. Apart from the questionnaire there were two other data sources:

- Students marks from the School of Computer Science;
- Information from the University of the Witwatersrand Academic Information Systems Unit.

The following steps were taken to clean the data:

- Students registered for the HDIP were removed from the sample. The decision was made early on in the study to focus on only Computer Science first year (CS I) students so as to provide a more homogeneous sample than if the HDIP students were included. The HDIP students were all graduates and thus generally older, more mature students who were studying a few ad-hoc courses. In addition, it transpired that a number of the HDIP students were in the pilot group of Computer Science second year students and therefore they had answered the questionnaire twice. Thirteen HDIP students were removed from the sample.
- One record was removed as no student number was provided so I was unable to relate the questionnaire responses to class and exam marks or to the information provided by the University of the Witwatersrand Academic Information Systems Unit.
- In a few instances incorrect student numbers had been captured. To merge the four parts of the questionnaire as well as the students' marks, all the student numbers had to be checked. This was done by sorting the various sheets by student number and checking the information line by line and identifying and fixing any errors.

The questionnaire has been discussed in some detail, from the rationale for the questionnaire through to the capture and cleansing of the data obtained from the questionnaire. In the next section, the second instrument, namely the interview, is discussed under the same headings used to discuss the questionnaire.

4.6 The Interview

An interview with open-ended questions was selected as the instrument to use for the ethnographic research.

4.6.1 Rationale for interviews

The structured questionnaire discussed above provided a summary and overview of the learning style and approaches adopted by the students. From a qualitative perspective, in order to obtain a deeper understanding of the learning approaches of students, a number of interviews were conducted. Some of the benefits of an interview and the reasons for selecting the interview as an instrument are outlined below:

- Allow for **greater depth** (Cohen and Manion 1980). I wanted to understand in detail how students who are struggling with the FAC course approach their studies. McCune and Entwistle (2000) note that questionnaires on approaches to learning have provided a good high level summary of how students study, but that "observed behaviour and interviews suggest the importance of the idiosyncratic details of students' learning and of the complex effects of differing learning environments" (McCune and Entwistle 2000, pg 4). Therefore, in order to understand the distinctive approaches that students use whilst studying a particular course, namely FAC, a number of students were interviewed.
- **"Gain entry into their world".** An interview provides "access to what is 'inside a person's head'" (Cohen and Manion 1980, pg 292 quoting Tuckman.). As noted by Booth (1992) this is particularly important from a phenomenographic perspective. Booth (1992) elaborates that the semi-structured interview is the most appropriate type of interview for phenomenographers.
- Suitable for **open-ended** questions. The interviewer can keep the respondents motivated to answer the question (Schumacher and McMillan 1993). If an open-ended question is asked in a questionnaire, respondents are likely to fill in the answer in a hurry, whereas an interview can be conducted at an appropriate speed (Cohen and Manion 1980).
- **Honest answers:** Cohen and Manion (1980) note that according to Kitwood (1977) "it is believed that in an interpersonal encounter people are more likely to disclose aspects of themselves, their thoughts, their feelings and values, than they would in a less human situation."

Although, based on the information I wish to discover, an interview is an appropriate instrument, interviews have a number of limitations and disadvantages that must be addressed. The way the weaknesses of interviews were addressed is discussed in the next sections.

4.6.2 Design of the interview schedule

A copy of the interview schedule is attached as Appendix G. The interview schedule has seven parts:

1. **Introduction:** I first introduced myself and thanked the student for his / her time. I also explained the purpose of the interview and highlighted that I believed the interviewee's views would contribute to improving the FAC course.
2. The **Confidentiality and voluntary** nature of the interview was stressed to the interviewees. I also asked for their permission to use a tape-recorder.
3. **Background:** The purpose of these background questions was to try and get the student to feel relaxed and comfortable. Both Schumacher and McMillan (1993) and Cohen and Manion (1980) recommend that easy questions should be asked first in order to relax the interviewee and establish a relationship before the key questions are asked. I had planned not to transcribe or research the answers to these questions, but, based on the interesting responses, the answers to these questions were analysed.
4. **Learning Style:** The objective of this interview question was to confirm or refute the results of the ILS. Felder and Solomon (2004a) advise that "If someone does not agree with the ILS assessment of his or her preferences, trust that individual's judgement over the instrument results".
5. **Learning Approaches:** These three open-ended questions are the focus of the interview. The questions were based on Ramsden (1992, pg 51) and discussions with the FAC course lecturer (April 2004).
6. **Probing of the Questionnaire:** This section was included after the pilot interview. The objective was to clarify any items of interest in the questionnaire answered by the particular student.
7. **Closing:** I thanked the interviewee for his / her time and asked if they had any questions they would like to ask me.

In addition to designing the interview schedule other preparation for the interview sessions was required, this is discussed in the next section.

4.6.3 Preparation for the Interviews

The following preparation was completed prior to conducting the interviews:

- **Ethical approval:** Approval of the interview schedule was obtained from the Computer Science Ethics Committee at the same time that the research project and questionnaire were submitted for approval.
- **Familiarity with the material to be covered:** I was not familiar with some of the material and therefore needed to study parts of the FAC course so that I could understand the responses from the students.
- **Pilot:** One of the students from the FAC class was selected for a pilot interview. There are a number of reasons to pilot an interview:
  - As noted by a number of authors including Schumacher and McMillan (1993) and Oppenheim (1996), a pilot interview enables the logistics to be tested and the length of the interview to be assessed. The pilot interview was much shorter than I had anticipated. This enabled me to include an additional part to the interview schedule to explore more deeply some of the answers the interviewees had given in the questionnaire.
  - Powney and Watts (1987) note that a pilot interview provides an opportunity for the interviewer to practice interview skills with the particular questions. I identified that I needed to probe more deeply, and therefore in the main interviews I probed more than I had in the pilot interview.
  - Oppenheim (1996) notes that a pilot interview helps with the actual wording of the questions. In the pilot interview I found it difficult to expand on some of the questions, therefore, in the main interview, I took some sample material in the form of examples from tutorials to assist with explaining some of the questions.
  - Schumacher and McMillan (1993) note that a pilot interview is used to assess the ease of summarising and analysing the data. When summarising the results of the pilot interview I started to identify the themes to use to analyse the data.

A particular area requiring preparation was the selection of the interview sample. This is described in the next section.

4.6.4 Sample selection

The target population is FAC students within the School of Computer Science at the Wits. According to Schumacher and McMillan (1993, pg 166) “in exploratory research a smaller sample size is acceptable.” Therefore in order to manage the scope of the research project a decision was made at the time of preparing the proposal to limit the sample size

to five. However, I was advised that students often do not turn up for interviews and I therefore decided to make appointments with a few extra students.

Purposive sampling was used to select the students to be interviewed. Case and Gunstone (2002, pg 463) note that their primary data collection method was a "series of five or six in-depth individual interviews with 11 students" and that purposive sampling was used to select the students. Booth (1992, pg 58) comments that "by far the most common form of collecting material for phenomenographic research is by holding interviews with a sample of the population of interest – not a random sample but a choice made to represent the population in some theoretically appropriate way." According to Neumann (1997), purposive sampling is used to select respondents that are especially informative and with a particular purpose in mind. The primary purpose was to understand the learning approach adopted by students who are struggling with the FAC course. Therefore it was considered that respondents who are struggling with FAC would be particularly informative.

As defined in chapter 1, for the purpose of this research project, a struggling student is a student who is working hard and making great efforts, but whose marks are borderline and therefore he / she is in danger of failing the course, but he /she appears to have the potential to pass. With the assistance of the FAC course lecturer, a sample of nineteen (19) students was identified that were considered "struggling students." When this potential sample was identified, very little was available in the way of course marks. Therefore the FAC lecturer identified students who were participating in lectures and putting in great effort in the tutorial / laboratory sessions, but were not showing the insights the FAC lecturer would like to have seen. This was a very subjective approach, but was deemed suitable to identify potential students for interviewing. All these students had an average mark greater than 38% for the two FAC tests, that is these were not the weakest students in the class as 28% of the class had less than or equal to an average of 38% for the two FAC tests.

As one of the functions of the interviews was to check and corroborate the results of the responses in the questionnaire, only students who had completed the questionnaire were considered as possible interviewee candidates. The questionnaire was administered at the end of a lecture period, therefore, excluding students on this basis was justifiable as it was viewed that students were not participating and working hard (part of the definition

of a struggling student) if they were missing lectures. It was established that twelve (12) of the nineteen (19) struggling students had completed the questionnaire, i.e. seven students had not completed the questionnaire and were therefore excluded as possible interviewee candidates.

My aim was to interview as representative a sample as possible. More than 80% of those who responded to the questionnaire were male and approximately 65% were black. However, when I tried to contact the students I found that some of the black students were difficult to contact as they did not have telephones. The students for interviewing were therefore selected in the following manner:

- Three of the students could not be contacted, thus reducing the available number from twelve to nine students.
- Of these nine students, three were white females, and as the majority of the FAC class were males I chose to only interview one white female, eliminating a further two students from the list.
- There were two white males, and as there are more blacks in the FAC class, I chose to only interview one white male, eliminating a further student from the list.
- This left six "struggling" students, all of whom were interviewed.

My resultant sample was: 3 males and 3 females; 4 blacks and 2 whites, split as follows:

- Black male: 2
- Black female: 2
- White male: 1
- White female: 1

Although ideally I should have interviewed more males and fewer females, this split was viewed as sufficiently representative of the class to provide some insight into the learning approaches of the students. Powney and Watts (1987, pg 189) question to "what extent can any one interview be said to be representative of a group" as some individuals may be happy to be classed in a certain way, for example black, and others may strongly resent it. Powney and Watts (1987, pg 190) therefore conclude that "the researcher must be very careful in interpreting interview data and in particular in the kind of general statement they make as they summarise interview outcomes". Thus, even though I have

selected a fairly representative or illustrative sample, I will take care in my analysis not to make inappropriate generalisations.

In order to get an understanding, and potentially a comparison, of the learning approaches of students who were excelling in the FAC course, I decided that it would be beneficial to interview a few excelling students. An excelling student was considered to be a student who had obtained high marks for the two FAC tests that had been written. Five students were identified who had obtained greater than an 80% average for the FAC tests. Only two of these students had achieved greater that 85% for each of the FAC tests. This was important, as the second test was considered considerably more difficult than the first test as a deeper understanding of the material was required and less rote learning. One of these students had not responded to the questionnaire so the one student who had both responded to the questionnaire and achieved greater that 85% for each of the FAC tests was interviewed. From the other three excelling students, one student was selected for the pilot interview. Although an excelling student was not an ideal example of the sample to be interviewed, I decided to use an excelling student as the pilot sample so as not to reduce the available number of struggling students for the main interviews. The pilot interview was administered without any problems and I therefore decided to include this data. The resultant sample of excelling students was two white males.

All students contacted agreed to participate in the interview and arrived for the interview. Thus there is no bias related to willingness to participate.

Once the FAC course mark was available two of the students previously viewed as struggling students were reclassified as competent students. That is two students obtained 70% for the FAC class mark and an overall FAC course mark greater than 65%. The characteristics of the interview sample are described in chapter 7. In the next section the process to collect the data, that is conduct the interviews, is described.

4.6.5 Data collection process

As recommended by Mouton (2001, pg 104) " it is imperative that you document your data collection process as accurately and in as much detail as possible". I have therefore recorded below the setting, date and timing, plus the method I adopted to set up

interviews as well as a diary of events and how I conducted the actual interview. Notes were kept on a daily basis.

4.6.5.1 Setting

According to Thompson (1978) it is important to carefully choose the setting for the interview. For example, the conditions should be as similar as possible for each interview and the venue should help make the respondent feel at ease. Taking this into account, all interviews were held in the same small meeting room on campus. It was a suitable venue as it was private which should have assisted in encouraging honesty from the interviewees. The room was clean and had a table and a few chairs. The small room with simple furnishings helped put the students at ease. The students could also locate the room with ease.

4.6.5.2 Dates and timing

The interviews were conducted on the 25th and 28th May 2004. This period was selected as it was at the end of the FAC course, in the last week of the second term prior to study break, and two weeks after the questionnaire had been administered.

Care was taken to keep the interviews to a reasonable length so that the students did not become bored or unfocused. The interviews therefore took between 20 and 35 minutes each. For contingency I had initially scheduled the interviews an hour apart, but based on the experience of the pilot interview the interviews were rescheduled to occur at between 30 and 45 minute intervals. Four students were prompt, 2 students arrived early and only one student was a few minutes late as he had to walk from a lecture that was located a distance from the interview venue.

4.6.5.3 Setting up interviews

I did not want to contact students during or after a lecture as their anonymity would be compromised. The following method was therefore adopted to set up interviews with the students:

- Where available, the following contact details were obtained for each student from the School of Computer Science secretary: land telephone number, cell / mobile number and email address.

- Some contact details were incorrect and a number of friends or relatives of the students had to be phoned to obtain the students' contact details.
- All students on the list, that is except the three noted above that could not be reached at all, had cell phones. Calling students on their cell phones was therefore selected as the best way to get in touch with the students to arrange interviews. One student was only contactable through his friend's cell phone. This did not prove to be a problem, but meant that sometimes I had to phone more than once to find out when the friends would be together.
- After trying various times during the day and getting no replies, I found that a good time to contact students was after 5pm.
- I established that it was difficult to find times that both the students and I were mutually available. Science students have long days and very few free periods. By speaking to two students I established which days students were likely to be available and blocked out two days in my work diary for the following week (a Tuesday and Friday)
- To reduce the likelihood of students not turning up for interviews I phoned students to confirm the date and venue and sent an sms (short message service) to their cell phone confirming the date, time and venue of the interview so that they had the information readily to hand. Two students sent sms replies to me. The phone-calls proved useful as one student advised that he could not make the interview at the scheduled time as he had a lecture. The interview was rescheduled to a suitable time.

All of the students arrived promptly for the scheduled discussion (interview). I believe the thorough and systematic approach discussed above contributed significantly to this. A diary of the events associated with the interview process is attached as Appendix H.

4.6.5.4 An exception

On completion of all the interviews I sorted out the tapes and made copies of the tapes for back-up purposes. I found that I had not taped the interview with the excelling student. When I thought I turned on the record button, I had turned on the play button and this was not noticed. I thought of re-interviewing the student, but decided against this as a second interview could bias the results. I decided to use an alternative method of recording the results of interviews and wrote notes based on memory. I then contacted the excelling student and explained the situation and asked if he would check my notes. He made the

following comment regarding my notes: “generally, I think it’s a great reconstruction of our discussion, but there are a few minor additions.” His comments were checked and added to my notes where appropriate.

4.6.5.5 During the interview

I conducted all the interviews and when asking the questions during the interview, the advice below from various experts was followed:

- The questions were asked in a natural way so that the students felt at ease (Cohen and Manion 1980).
- The interviewed students were given sufficient time to answer the questions (Thompson 1978).
- The same sequence of questions was followed in each interview (Schumacher and McMillan 1993).
- I tried to ensure that none of my own bias would affect the responses from the students. I tried not to show any surprise or confusion to a response and avoided expressing my own views or opinions verbally or with body language (Cohen and Manion 1980).
- I used probing as required and ensured that the probing was neutral so as not to affect the student’s responses (Schumacher and McMillan 1993).

To get honest responses, it was important that the interviewed students felt at ease and comfortable with the interviewer. As previously noted I therefore started with easy background questions. Following advice from (Schumacher and McMillan 1993) I also dressed in a casual manner rather than a formal work suit. I tried to be friendly, pleasant and relaxed and showed an interest in the student’s welfare.

In the next section the procedure used to capture the data during the interview and following the interview is described.

4.6.6 Data capture

Schumacher and McMillan (1993) outline a number of the benefits of using a tape-recorder. A tape-recorder is particularly useful with open-ended questions. Given the structure of the interview schedule I decided to use a tape-recorder so as to collect as complete a record as possible of the students’ responses as well as objective a record as

possible. In addition, the recordings can be reviewed by a number of people, for example future researchers, if required.

In addition to the advantages of using a tape-recorder there are disadvantages which Posner and Gertzog (1982) draw attention to. For example a tape recorder may affect the interviewee's responses and the recording takes time to transcribe. Based on the time required to transcribe the tape-recordings, I decided to use a person both skilled in the process of transcribing interviews and who had the appropriate equipment to do so. I requested a quick turnaround so that I could review the transcriptions whilst the interviews were still fresh in my mind. The transcriptions were received back within two weeks of the interviews. A sample transcription is attached as Appendix I.

Once the data has been captured and transcribed it needs to be checked. The data cleansing carried out is described in the next section.

4.6.7 Data cleansing

In parallel with the transcriptions being done, I listened to the tapes a few times to get a high level view of the students' responses. Unfortunately, some of the students spoke quite softly, and, as I had wanted to minimise the impact of the tape recorder on the students' responses and had not wanted the tape-recorder to distract the students, I did not place the tape-recorder directly in front of the students. The consequence was that at times the students' responses were not clear. [xxxx] was used to denote where the response by the student could not be heard.

To reduce possible errors I checked the transcriptions in detail. Two main types of errors were detected. The first was where the transcriber did not have sufficient knowledge of the material and as the students did not always talk clearly the incorrect term was typed, for example the following had been transcribed:

> *"the most interesting type of graph is like binary and trade yeah so I like prepare much, I do much binary, trade and others."*

whereas it should have been:

> *"the most interesting type of graph is like binary tree, yeah so I like prepare much, I do much binary trees and others."*

The term "tree" and been mistakenly typed as "trade". This type of error could be identified and corrected quite readily by myself who had knowledge of the topic.

The second type of error was more difficult to detect and potentially more serious as the incorrect transcription had a different meaning to what the student had actually said, for example the following had been transcribed:

> *Yeah I agree also, because when I was doing [xxxxx] I got the [xxxx] if you want to understand your work then you must use books and part of your brain and so on, that's why I like seeing pictures, drawing maps and just get it from pictures*

whereas it should have been:

> *Yeah I agree also, cause when I was in matric I got the [xxxx] who told me that if you want to understand your work then you must use both parts of your brain and so on, that's why I like seeing pictures, drawing mind-maps and just get it from pictures*

The emphasis was on using both parts of your brain and not on using books.

These two examples highlight the rationale for the interviewer ideally transcribing the tape-recordings themselves, or alternatively checking the transcription against the original tape-recording as diligently as I did and correcting errors. However, it must be noted that the original interviewee can also make human errors and therefore the whole document should be reviewed for consistency. The individual paragraphs should not be analysed only in isolation as the whole is greater than the sum of the parts. This is picked up in chapter 7 when discussing the method used to analyse the interviews.

Finally, Schumacher and McMillan (1993) advise that as soon after the interview as possible any notes taken during the interview should be expanded upon. Since I had used a tape-recorder to record the students' responses, I had only written a few notes during each interview. Within four days of the first set of interviews and one day of the last set of interviews I wrote brief notes on any aspects that would not be picked up from the

tape-recoding, for example promptness of students, tone used by students and willingness of students to participate.

To verify the interviews, I asked the students if they would check the transcriptions and confirm that they were a correct reflection of our discussions. Unfortunately the students were on exam leave and then vacation and so there was a large gap before I could get copies of the transcriptions to the students. Six of the seven students received the transcriptions and confirmed that they were a correct reflection of the discussions. I was unable to reach one of the students interviewed. However, as all the other students had noted that no corrections were required to the transcripts I assumed that all the transcripts were a correct reflection of the interviews.

Upon completing the capture and cleansing of the data the next step was to analyse the data, the method followed is described in chapter 7. In the next two sections some comments are first made on the statistical techniques used when analysing the data from the questionnaire and then on the reliability and validity of the research study.

4.7 Statistics

The Microsoft Excel package was used to statistically analyse the results from the various questionnaires. Based on the literature reviewed (Mendenhall and Ott 1980; Finnie 1987; Chamillard and Karolick 1999; Van Zwanenberg 2000; Thomas et al. 2002) Pearson's Correlation Coefficient as well as *t*-tests were deemed appropriate.

Correlations were calculated to give an indication of the linear relationship between sets of variables. Chamillard and Karolick (1999, 293) highlight that "correlation is not a measure of causality; it simply measures the linear relationship between two variables". They also note that "a low correlation only indicates that the variables are not linearly associated; they could still be related in some non-linear way". For this reason I often plotted the data so that any obvious visual relationship could be observed.

The two-sample *t*-test, assuming unequal variances, was used to examine if the results obtained for two different groups were statistically significantly different. An example of the procedure followed is provided below. This procedure was theoretically followed whenever the two-sample *t*-test was calculated.

- The research hypothesis was formulated, for example: there is a difference between the two means of two groups.
- The correlation between two sets of variables was calculated. If there appeared to be some level of correlations, for example r >0.25 or r <-.25 then further analysis was warranted.
- In order to use inferential statistics, the null hypothesis (H_0) was formulated. For example, $H_{0:}$ there is no difference between the means of the two groups, (that is the means of the two groups are the same.)
- The *t*-test was then calculated and the *p* value examined. If a *p* value less than 0.1 was calculated then the null hypothesis was rejected and the statement was made that there was a statistically significant difference between the two means of the two groups. The *p* value was always quoted which gave an indication of the level of confidence in the result. For example a *p* value of 0.05 indicates that the null hypothesis is rejected with a 95% confidence level.

4.8 Validity and Reliability

It is pointless carrying out the research study described above if the results are not valid and reliable. In the above section 4.5.2.1, when discussing the instrument used to determine the learning style preferences of students, the reliability and validity of the particular instrument selected, the ILS, was discussed. Unfortunately no information is available on the reliability and validity of the learning approach instrument used. Due to the nature of my research, in this section, the concepts reliability and validity are considered primarily from a qualitative perspective.

Some qualitative researchers have argued that the term validity is not applicable to qualitative research (Golafshani 2003). This argument is not debated in this report and for simplicity the terms validity and reliability have been used, but their meanings from a qualitative perspective are defined.

Winter (2000) notes that a much cited reference of validity is that provided by Hammersley: “An account is valid or true if it represents accurately those features of the phenomena, that it is intended to describe, explain or theorise.” For me the key aspect has been, am I researching what I think I am? To this end I have studied literature on the

topics under research, and, in the analysis chapters, I have attempted to describe accurately and in detail the results and to consider various alternatives for the findings.

"Reliability is the extent to which independent researchers could discover the same phenomena and to which there is agreement on the description of the phenomena between the researcher and the participants" (Schumacher and McMillan 1993, pg 385). As explained by Booth (1992, pg 64) "if another researcher repeated the research project you have just carried out, what is the probability that he or she would arrive at the same results, the same categories of descriptions and conceptions?" In order to address these issues the qualitative researcher must take special care in the design of their studies, the data collection, processing and analysis. The qualitative researcher must ensure that there is a detailed record of what, when and how the research was conducted. This is the reason for the amount of detail provided in this chapter.

4.9 Concluding Remarks

Based on a good understanding of how, where, when and with whom the research was conducted it is now time to analyse and discuss the results of the study. There are three chapters that analyse the results of the research. In chapters 5 and 6 the results of first the learning style questionnaire and then the learning approach questionnaire are analysed. In chapter 7 the interviews are analysed.

5. ANALYSIS OF LEARNING STYLE QUESTIONNAIRE RESULTS

5.1 Introduction

The proceeding chapters have provided an understanding of the aim of the study and the FAC course at Wits, what the literature has to say on learning and learning styles as well as an overview of the sample group. With this background, this chapter provides an understanding of the results and findings obtained from an analysis of the learning style questionnaire.

The analysis of the data collected from the administration of the ILS to the sample group of 99 FAC students is presented. The method used to process and analyse the data is first outlined. In order to answer the research questions: "What are the various learning styles of students studying the FAC course?" and "what, if any, relationship is there between learning approaches, learning styles and student success?" the data is analysed from a number of perspectives.

5.2 Data Processing

In Chapter 4, the method used to capture and clean the data from the four parts of the questionnaire was explained. In this section, the data processing specific to the ILS is described.

To recap, the ILS (Index of Learning Styles), which assesses students' learning style preferences according to the Felder-Silverman Learning Style Model, was selected. A copy of the instrument is attached in Appendix D. A sample item is shown below in Figure 5.1

12. When I solve math problems

a) I usually work my way to the solutions one step at a time.

b) I often just see the solutions but then have to struggle to figure out the steps to get to them.

Figure 5.1 Sample item from the ILS

The students were asked to:

- Please ring your answer (a) or (b) for each question.
- Please choose only one answer for each question. If (a) and (b) seem to apply to you, choose the one that applies more frequently.
- There are **no** correct answers so please respond by giving your own honest opinion so that your answers will **accurately** describe your **learning style.**
- Please answer every question.

For a particular question, if a student provided no response, or circled both responses (a and b), the response for the specific question was left blank. Out of a total of 4,356 responses, there were only 55 responses, equating to less than 1.3%, where invalid responses were provided. There were 19 returned learning style questionnaires, equating to 19%, where one or more responses were invalid. Of these 19 questionnaires, ten had one invalid response. At the upper limit, one questionnaire had 13 invalid responses. Due to the method (described below) of determining the learning style preferences of the students from the responses, no returned learning style questionnaires were eliminated from the sample. In hindsight, due to the interval scale used, ideally I should have eliminated the questionnaire with 13 invalid responses. However, fortunately, on examining the impact on retaining this questionnaire it was noted that the implication was minor as the result was the computation of low values for the learning style dimensions of one student.

The ILS consists of 44 forced-choice items, with each option ("a" or "b") corresponding to one or the other category of the dimension. Each learning style dimension has 11 questions associated with it and each question contributes to only one of the four dimensions. The method used to compute the total scores for each dimension is according to the method used by Felder and Solomon (2004a). Total scores for each dimension are computed by summing the scores of the "a" answers for relevant questions and subtracting the sum of the "b" answers for the relevant questions. (or vice versa if the "b" total is greater than the "a" total). An example is provided in Table 5.1. The Felder-Silverman model classifies students as having preferences for one category (for example active) or the other (for example reflective) in each of four dimensions.

Table 5.1 An example of calculating the learning style scores for a student

Active / Reflective			Sensing / Intuitive			Visual / Verbal			Sequential / Global		
Q	**a**	**b**	**Q**	**a**	**b**	**Q**	**a**	**b**	**Q**	**a**	**b**
1	1	0	**2**	1	0	**3**	1	0	**4**	1	0
5	1	0	**6**	1	0	**7**	1	0	**8**	0	1
9	1	0	**10**	1	0	**11**	1	0	**12**	1	0
13	0	1	**14**	0	1	**15**	1	0	**16**	1	0
17	0	1	**18**	1	0	**19**	1	0	**20**	1	0
21	1	0	**22**	0	1	**23**	1	0	**24**	0	1
25	1	0	**26**	1	0	**27**	1	0	**28**	0	1
29	0	1	**30**	1	0	**31**	0	1	**32**	0	1
33	0	1	**34**	0	1	**35**	1	0	**36**	0	1
37	0	1	**38**	1	0	**39**	1	0	**40**	0	1
41	0	1	**42**	0	1	**43**	1	0	**44**	0	1
Total per category	5	6		7	4		10	1		4	7
Overall score	0	1		3	0		9	0		0	3

In the examples below, the line referred to in Table 5.1 is the "Overall score" highlighted in blue. For each student a value on a nominal scale and interval scale were determined.

For each of the four dimensions a value on a **nominal scale** was determined indicating if the student was active or reflective, sensing or intuitive, visual or verbal, sequential or global. For example:

- On the active / reflective dimension an overall score of 1 under the "b" column in Table 5.1 represents a reflective learner;
- On the sensing / intuitive dimension an overall score of 3 under the "a" column in Table 5.1 represents a sensing learner.

A **profile** is a combination of the four dimensions. The profile of the student depicted in Table 5.1 is reflective, sensing, visual and global.

For statistical analyses the nominal values were converted to a "1" or "0". For example: on the sensing / intuitive dimension in Table 5.1, a "1" was entered in the column (field) titled "sensing" and a "0" in the column (field) titled "intuitive".

For each dimension a value was also calculated that gave an indication of how strong or low the student's preference was in the particular dimension **(interval scale)**. For example:

- on the visual / verbal dimension an overall score of 9 under the "a" column in Table 5.1 represents a strong preference for visual learning;
- on the sequential / global dimension an overall score of 3 under the "b" column in Table 5.1 represents a low preference for global learning.

For statistical analyses the values on the interval scale were treated as running from –11 to +11. For example:

- on the visual / verbal dimension in Table 5.1, the value used was –9
- on the sequential / global dimension in Table 5.1, the value used was +3

Based on the data described above, in the next section, the procedures used to analyse the data are explained.

5.3 Data Analysis

The methods used to analyse the data are based on studies by various researchers identified during the literature review.

The learning style preferences were tabulated. Firstly, using the nominal scale values, the number of students per each category was calculated. This provided an overview of the learning style preferences of the sample. The research results were compared against the results from other similar studies. Then, using the interval scale values, the learning style preferences of the sample population were determined according to the strength of the reported preferences. This provided some detail per learning style dimension. The research results were again compared against the results from other similar studies.

To explore aspects of the third research question: "what, if any, relationship is there between learning approaches, learning styles and student success?" the relationship between learning style preferences and FAC course marks were investigated from a number of perspectives. The two-sample *t*-test, assuming unequal variances, was used to examine if the results obtained for two different groups were statistically significantly different.

Finally the data was analysed to see if there were any relationships between the learning style preferences and demographic factors such as gender and population group.

In the next section, the results and findings based on the data analysis outlined above are presented and discussed.

5.4 Findings

In this section the results and findings of analysing the sample data from a number of perspectives are presented:

1. Overview of the learning style preferences (section 5.4.1)
2. Details per learning style dimension (section 5.4.2)
3. Orthogonality of the four dimensions (section 5.4.3)
4. Predominant learning style profiles (section 5.4.4)
5. Relationship between learning styles and FAC course marks (section 5.4.5)
6. Relationship between learning styles and demographic factors (section 5.4.6)

5.4.1 Overview of the learning style preferences

Using the nominal scale, an overview of the learning style preferences of the students in the sample population was obtained. That is, each student was active or reflective, sensing or intuitive, visual or verbal, sequential or global. The number of students in each category per dimension is shown in Table 5.2

Table 5.2 Overview of the learning style preferences for the sample group

Number	Category	Category	Number
37	*Active*	*Reflective*	61
57	*Sensing*	*Intuitive*	40
80	*Visual*	*Verbal*	19
54	*Sequential*	*Global*	44

Although the sample size was 99 students, in Table 5.2 the total does not add up to 99 for each dimension as, in some cases, a student obtained a score of zero indicating no preference for either category of the particular dimension.

From Table 5.2 it is evident that, in the sample population, a student has five times the likelihood of being visual rather than verbal. A student has almost twice the likelihood of being reflective rather than active. Felder and Spurlin (2005) summarise the learning style preferences reported in different studies. For comparison purposes some examples from Felder and Spurlin (2005) are provided in Table 5.3.

Table 5.3 Reported learning style preferences

Sampled Population	Active	Sensing	Visual	Sequential	N
FAC students	**37%**	**57%**	**80%**	**54%**	**99**
Iowa State, Materials Eng	63%	67%	85%	58%	129
Michigan Tech, Env, Engr.	56%	63%	74%	53%	83
Ryerson Univ. Elec. Engr. 2002	63%	63%	89%	58%	132
Tulane, Engr. First-year students	56%	46%	83%	56%	192
Universities in Belo Horizonte (Brazil), science students	65%	81%	79%	67%	214
Univ. of Puerto Rico-Mayaguez Elect. & Comp. Engr	47%	61%	82%	67%	?
Univ. of Sao Paulo, Elec. Engr.	57%	68%	80%	51%	91

Apart from the figures for the FAC students (highlighted in grey), all figures given in Table 5.3 are from the paper by Felder and Spurlin (2005). In Table 5.3 if 37% of students are shown as active learners, then by implication 63% were classified as reflective learners.

From the examples in Table 5.3, (the pertinent column is highlighted in green), it is evident that the strong preference for the visual learning style, for the sample population, is comparable with the preference of engineering and science students summarised by Felder and Spurlin (2005). Although a slightly different method was used to calculate the results, a similar trend was evident in the results reported by Van Zwanenberg et al.(2000).

However, the low number of students in the sample population that had a preference for the active learning style (the pertinent column is highlighted in orange in Table 5.3) was not evident in the results summarised by Felder and Spurlin (2005). Similarly the results

reported by Van Zwanenberg et al. (2000) were not aligned with the results of the sample population. The results reported by Van Zwanenberg et al. (2000) showed that the students who responded in their research had a stronger preference for the active learning style. The sample population distribution for the active / reflective dimension was also not present in a study carried out by Chen (2003) with first year Computer Science students at Wits. Using Kolb's Learning Style Inventory, Chen (2003) found that an equal portion of the students were active as reflective. I have been unable to explain why the research sample population displays a different preference in the active / reflective dimension to that evident in other studies. The active / reflective dimension is discussed in more detail in the sections below.

5.4.2 Details per learning style dimension

For each of the four learning style dimensions, the possible scores were combined into class intervals and the frequency of the scores obtained by the students per each interval was tallied. The following intervals were used:

- High
- Medium
- Low

The histograms for each of the four dimensions are presented in Figures 5.2 to 5.5.

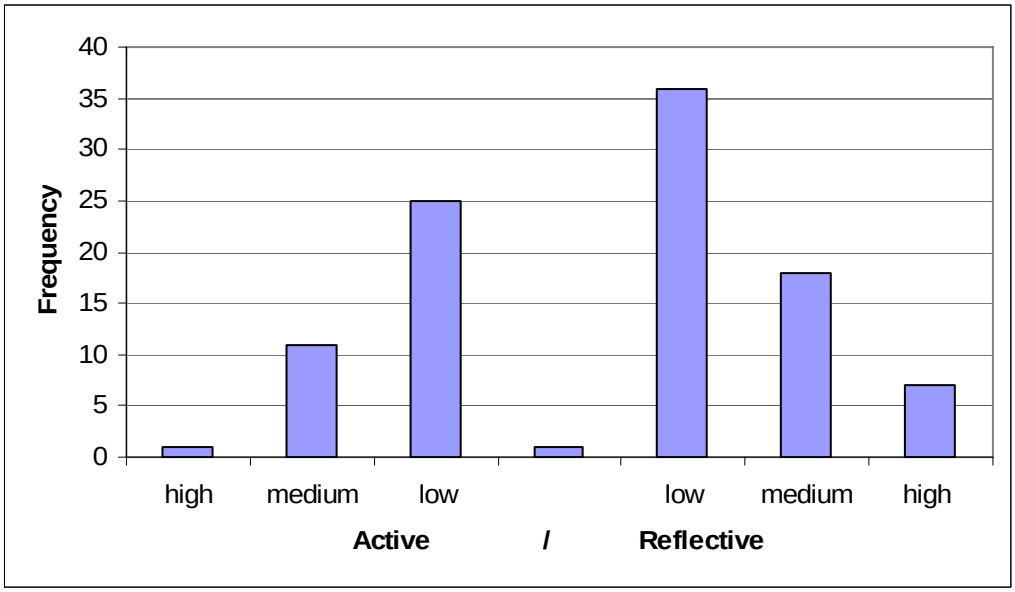

Figure 5.2 Histogram of the active / reflective learning style dimension

Referring to Figure 5.2 above, it is observable that although twice the number of students are reflective than active, a large number of the reflective and active students have low scores, indicating no strong preference for either dimension. A few students obtained a score of zero indicating no preference for either category of the dimension.

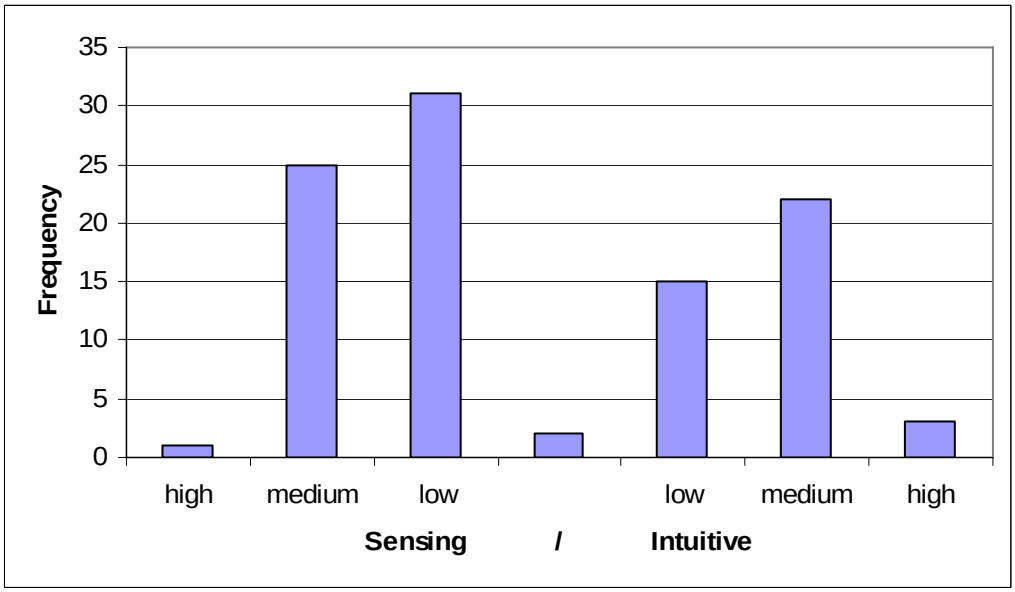

Figure 5.3 Histogram of the sensing / intuitive learning style dimension

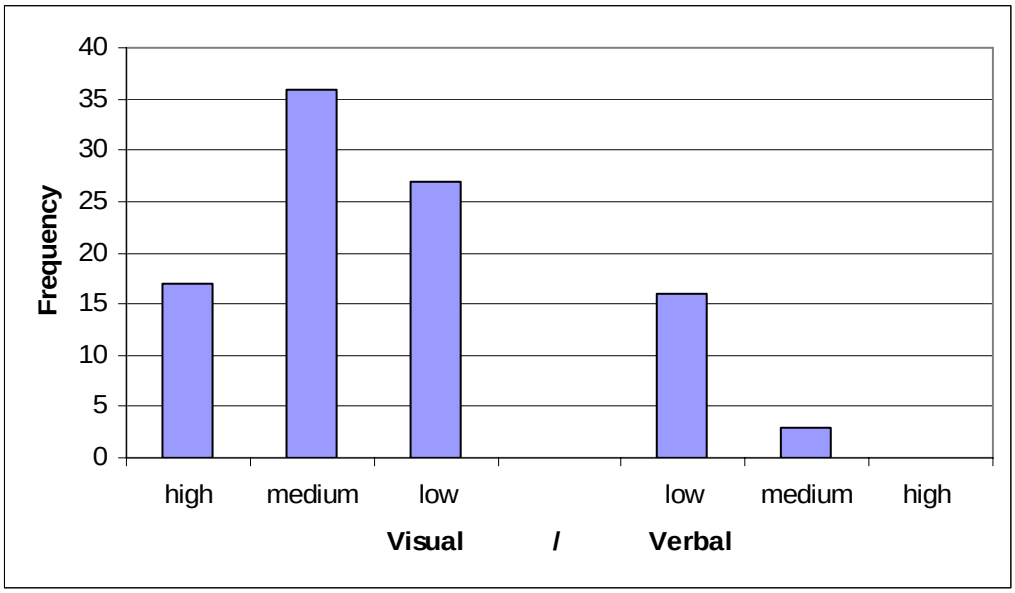

Figure 5.4 Histogram of the visual / verbal learning style dimension

Referring to Figure 5.4, the strong probability of being visual rather than verbal is observed, as well as the large number of students who obtained a medium visual score.

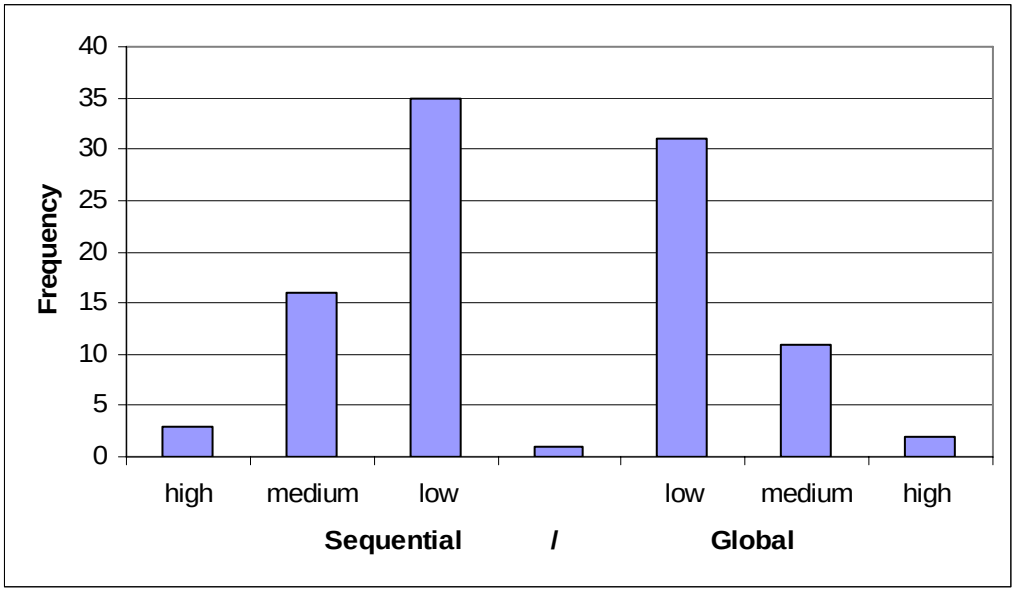

Figure 5.5 Histogram of the sequential / global learning style dimension

Referring to Figure 5.5, students score low on both categories of the sequential / global dimension, that is, there is no strong preference displayed by the sample students on this dimension.

Felder and Spurlin (2005) summarise the learning styles reported in various studies according to the strengths of the reported preferences. For comparison purposes some examples from Felder and Spurlin (2005) are provided in Table 5.4. Felder and Spurlin (2005) have used broader groupings than those depicted in Figures 5.2 to 5.5. The high and medium intervals for each dimension have been grouped together to indicate students with moderate to strong (MtoS) preferences in a dimension. The low interval on each dimension has been grouped together to indicate students with mild preferences.

Table 5.4 Strength of learning style preferences

Pop	Active - Reflective			Sensing - Intuitive			Visual – Verbal			Sequential - Global		
	MtoS	Mild	MtoS	MtoS	Mild	MtoS	MtoS	Mild	MtoS	MtoS	Mild	MtoS
A	12%	63%	25%	26%	49%	25%	54%	43%	3%	19%	68%	13%
B	30%	55%	15%	36%	49%	15%	62%	35%	3%	24%	62%	14%
C	31%	54%	15%	48%	38%	14%	38%	45%	17%	20%	69%	11%
D	25%	69%	6%	49%	46%	5%	46%	48%	6%	29%	64%	7%

Key: Pop = Population
A: Sample Population, N= 99 – highlighted in grey.
B: Ryerson University, Engineering Students, 2002 cohort, N= 132
C: San Jose State University, Engineering Students, N=183
D: Universities in Belo Horizonte, Brazilian science students, N=124

Table 5.4 shows large percentages of students with mild preferences across all dimensions and all studies. Also of interest is the relatively high percentage of students in the sample group with a moderate to strong preference for the visual learning style, (highlighted in pink on Table 5.4). Across three of the four quoted studies there is a very low percentage of students with a moderate to strong preference for the verbal learning style (highlighted in yellow on Table 5.4).

Since the research sample population has a different trend in the active / reflective dimension to that reported in other studies, it is worth analysing this dimension in a bit more detail. However, even if those students who obtained a mild score on the active / reflective dimension were removed from the population, it is still evident that a student has almost twice the likelihood of being reflective rather than active. This is still contrary to what is reported in other studies. In section 5.4.6 I will explore if this could be related to the racial mix of the sample population

Before examining the learning style profiles of the sample population, the orthogonality of the four learning style dimensions is investigated.

5.4.3 Orthogonality of the four dimensions

Felder and Spurlin (2005) comment that one would anticipate a moderate correlation between the sensing / intuitive and sequential / global scales. In particular, “global learners, whose thinking process tends to be nonlinear and who acquire understanding holistically, would seem much more likely to be intuitive than sensing” (Felder and Spurlin 2005, pg 104).

The results from the research support this expectation noted by Felder and Spurlin (2005). The correlation between the nominal scores for the sensing / intuitive and sequential / global dimensions is 0.34. Obtaining this type of expected result provides some form of reliability in the research results obtained. As expected, the other correlation figures calculated were small, for example the correlation between the nominal scores for the visual / verbal and active / reflective dimensions is 0.04. (Although the values were on the nominal scale, correlation coefficients were computed as both sets of values were nominal).

On examining the interval scale values for the sensing / intuitive and sequential / global dimensions the correlations in Table 5.5 were calculated. This shows that global learners are more likely to be intuitive than sensing. There is a negative correlation (-0.30) between global and sensing learners.

Table 5.5 Correlations between the sensing/intuitive and sequential/global dimensions

	Sensing	**Intuitive**
Sequential	0.32	- 0.28
Global	- 0.30	0.26

In the next section the learning style profiles of the sample group are examined.

5.4.4 Predominant learning style profiles

Based on four learning style dimensions there are 16 possible unique profiles. A profile is a combination of the four dimensions, for example: verbal, reflective, sensing and sequential. Although there are 16 unique possibilities, more than half (55%) of the entire sample falls within one of four profiles as shown in Table 5.6.

Table 5.6 Frequency of most prevalent learning style profiles

Active/ Reflective	**Sensing/ Intuitive**	**Visual/ Verbal**	**Sequential/ Global**	**Frequency**
Reflective	Sensing	Visual	Sequential	14
Active	Sensing	Visual	Sequential	15
Reflective	Intuitive	Visual	Global	15
Reflective	Sensing	Visual	Global	10

The learning style profiles of various groups of students as determined by their FAC grades are explored in the next section when exploring the relationship between learning styles and FAC course marks.

5.4.5 Relationship between learning styles and FAC course marks

To explore aspects of the third research question: “what, if any, relationship is there between learning approaches, learning styles and student success?” the relationship between learning style preferences and FAC course marks was investigated from a number of perspectives:

1. Within each learning style dimension, did students who favoured one category or another perform better?
2. By examining groups of students as determined by the students' FAC course marks, were there any preferences for particular learning styles?
3. The average class mark for each learning style profile was compared against the average class mark for the entire sample to assess if any particular profile was more successful than other profiles.

In the analysis presented and discussed below, nominal values are used for the learning styles, that is a student was either active or reflective, visual or verbal and so forth.

Within each learning style dimension, did students who favoured one category or another perform better?

A number of the studies reviewed analysed whether students who had a preference for a category of a learning style dimension performed better than students who had a preference for the alternate category. This was examined by comparing the average FAC course marks for students who favoured each category. The results are summarised in Table 5.7. (Shading is used in the table to separate the dimensions for ease of reading.)

Table 5.7 Summary of average FAC course marks for each category

Category	Course Mark	Standard Deviation	n
Overall Sample	52.27%	13.77	99
Active	50.70%	12.13	37
Reflective	53.13%	14.75	61
Sensing	51.65%	11.70	57
Intuitive	53.60%	16.26	40
Visual	51.15%	13.52	80
Verbal	57.15%	14.09	19
Sequential	53.40%	13.23	54
Global	50.61%	14.37	44

The only noteworthy difference, although not statistically significant (using the two tail *t*-test for unequal variances, p=0.10), that emerged from this analysis was that verbal learners scored higher than visual learners.

Although the differences are not statistically significant, it is worth highlighting that Felder's (1993) observation that engineering instruction favours those students who are reflective, intuitive, verbal and sequential is borne out in the results. This assumes that the

results of such bias would be higher achievement of those students with those learning styles.

Using the *t*-test, Thomas et al. (2002) compared students' learning style preference, as measured by the ILS, with their performance in an introductory programming course. The same pattern evident above was evident in their findings. That is that reflective learners scored higher than active learners (p=0.015); intuitive learners scored higher than sensing learners (no statistical significance); verbal learners scored higher than visual learners (p=0.027) and sequential learners scored higher than global learners (no statistical significance).

In agreement with the above results, Chamillard and Karolick (1999) found that Felder's active / reflective dimension had a positive correlation with most of the course performance scores, indicating that reflective students tend to do better in the course than active students. However, Chamillard and Karolick (1999) found few other significant correlations between Felder's other three learning style dimensions and the course performance scores.

Chamillard and Karolick (1999) found that Kolb's abstract conceptualisation (similar to Felder's intuitive dimension) had a strong correlation with the course performance scores, that is abstract learners tend to perform better in the course. This is aligned with the above results.

In the next section the relationship between learning style preference and FAC course marks are examined from a different perspective, that is were there any preferences for particular learning styles per homogenous groups of students where the groups were determined by the students FAC course marks?

What are the learning style preferences for particular groups of students?

In section 5.4.4 the learning style profiles of the entire sample population were presented. In this section the learning style profiles of different groups of students, as determined by their FAC course marks are explored:

Top students

An assessment of the top nine students in the sample group, that is the students in the sample group that obtained a course mark of greater than 70%, was made. The learning style profiles of the top, excelling students are shown in Table 5.8. The assessment indicated that the top, excelling students are notably more reflective (89% vs 61%) and intuitive (78% vs 40%) than the overall sample, (highlighted in yellow in Table 5.8).

Table 5.8 Learning style profiles of the top, excelling students

Active/ Reflective	Sensing/ Intuitive	Visual/ Verbal	Sequential/ Global	Frequency
Reflective	Sensing	Visual	Sequential	2
Reflective	Intuitive	Visual	Sequential	1
Reflective	Intuitive	Visual	Global	3
Reflective	Intuitive	Verbal	Sequential	1
Reflective	Intuitive	Verbal	Global	1
Active	Intuitive	Verbal	Sequential	1

These observations could be accounted for or explained by Felder's (1993) comments that engineering, and probably computer science, instruction favours those students who are reflective and intuitive. During an interview with the FAC lecturer it was determined that he does follow a predominately reflective approach in the lecture periods. However, this is only one explanation for the finding and there could be other valid reasons. For example, it could be the situation that a certain ethnic group is predominately reflective and this ethnic group achieves the highest marks in the FAC course. Some of these other possible relationships are explored in section 5.4.6.

Struggling students

As one of the aims of the research was to understand the profile of struggling students, the learning style profiles of students who had achieved borderline marks, that is marks between 45% and 55% for the FAC course, were examined. (It is not necessarily the situation that students who obtained borderline marks were "struggling students" in that these students may not have been working hard and making great efforts. However, for the ILS sample it was not possible to ascertain this second aspect of the definition for "struggling students", therefore students whose marks were borderline were used instead.)

Compared to the learning style profile of the entire sample group, the borderline / struggling students (n=31) are notably more sensing (77% vs 57%) and slightly more sequential (65% vs 54%) than the overall sample, (highlighted in yellow in Table 5.9). The preference for the sensing learning style by borderline /struggling students is opposite to that found for the top, excelling students for the intuitive style. This finding seems plausible as the FAC course is theoretical and requires innovation and abstract thinking whereas a student who has a preference for a sensing learning style is a concrete thinker who likes to memorise facts and solve problems using well-established methods.

Table 5.9 Learning style profiles of borderline / struggling students

Active/ Reflective	**Sensing/ Intuitive**	**Visual/ Verbal**	**Sequential/ Global**	**Frequency**
Reflective	Intuitive	Verbal	Sequential	2
Reflective	Intuitive	Visual	Global	3
Reflective	Intuitive	Visual	Sequential	1
Reflective	Sensing	Verbal	Sequential	2
Reflective	Sensing	Visual	Global	4
Reflective	Sensing	Visual	Sequential	7
Active	Intuitive	Visual	Sequential	1
Active	Sensing	Verbal	Sequential	1
Active	Sensing	Visual	Global	3
Active	Sensing	Visual	Sequential	7

There are no notable characteristics of the learning style profiles of students (N=29) who obtained a course mark less than 45%.

In the next section, the results are examined from a slightly different perspective. Instead of looking at groups of students and what learning style profiles they had, as done above, the predominant learning style profiles were studied to see if high or low grades were associated with a particular profile.

Was any particular learning style profile successful?

Thomas et al. (2002) looked at the 16 individual profiles, or groups, of students as determined by the four learning style dimensions. The average class mark for each profile or group was compared against the average class mark for the entire sample. I did a similar analysis. Using the two-tail *t*-test no statistically significant results were identified. However some interesting observations were made and these are summarised in Table 5.10. Some groups were very small and these have been omitted from the table.

Table 5.10 Analysis of learning style groups

Profile	**Course Mark**	**n**	**Comments**
Overall Sample	52.27%	99	
Reflective Sensing Verbal Sequential	56.29%	7	The group with the highest course mark. In the research by Thomas et al (2002) this profile of students was a very small sample (3), but achieved very high results.
Reflective Intuitive Verbal Sequential	55.00%	4	This group obtained the second highest course mark. This is the profile that Felder notes most lecturers favour. Note the very small sample size that falls within this "favoured" group.
Reflective Intuitive Visual Global	54.93%	15	High course mark, but profile includes the visual and global categories
Reflective Sensing Visual Sequential	54.50%	14	High course mark, but profile includes the visual and sensing categories
Reflective Sensing Visual Global	46.20%	10	The group with the lowest course mark. Apart from the reflective category, this profile is the opposite to what Felder notes most lecturers favour
Active Intuitive Visual Global	47.29%	7	The group with the second lowest course mark. Apart from the intuitive category, this profile is the opposite to what Felder notes most lecturers favour
Active Sensing Visual Sequential	48.87%	15	The group with the third lowest course mark. Apart from the sequential category, this profile is the opposite to what Felder notes most lecturers favour

The two groups that obtained the highest course marks were reflective, verbal and sequential learners. However, two other groups that obtained high course marks were visual learners. The only dimension common to the students that obtained good results was that they were reflective learners. However, reflective students also obtained low marks. Although the information in Table 5.10 is of interest, no unique profile was identified that was related to students being successful or unsuccessful.

As noted earlier, in the analysis reported on above, nominal values were used for the learning styles, that is a student was either active or reflective, visual or verbal and so forth. However, as shown in section 5.4.2 values on an interval scale have been

calculated and the degree to which a student is active or reflective, etcetera can be examined.

Using an interval scale, within each learning style dimension, did students who favoured one category or another perform better?

As the FAC course marks and the learning style scores for each dimension are all measured on an interval scale, Pearson's Correlation Coefficients were computed. A low positive relationship was found between class marks and reflective learners (0.2) and class marks and verbal learners (0.19).

It was noted in section 5.4.2 that there were a large number of students that had mild preference for the categories. Felder and Spurlin (2005) comment that "the students with mild preferences would be expected to shift between categories readily rather than consistently exhibiting behaviours associated with a single category, thereby masking differences that might appear in students with stronger preferences". Therefore, each dimension was examined independently, and students with a mild preference for a particular dimension were removed from the sample. For three of the four dimensions, no notable differences were detected between the correlation coefficient for the entire sample or the reduced sample. However, for the active / reflective dimension noteworthy results were obtained.

With students with a mild preference on the active/reflective dimension removed from the sample, the correlations between the active/reflective dimension (using an interval scale value) and course marks was 0.39. On analysing the data in more detail, it became evident that, on average, active learners (n= 12) obtained considerably lower course marks (45.17%) than reflective learners (55.48%, n=25). The results are statistically significant (p=0.02).

Although probably based on all the data, and not as above where students with a mild preference have been removed from the sample, there are a number of studies that report similar results. For example: Thomas et al. (2002) reported that reflective learners scored higher than active learners (p=0.015); Chamillard and Karolick (1999, 295) found that "reflective students tend to do better in the course than active students". In a similar vein, Finnie (1987, pg 5), using Kolb's Learning Style Inventory, found that "successful users (of the decisions support system) rated higher on reflective observation than did

unsuccessful". Referring to results from Honey and Mumford's Learning Style Questionnaire Van Zwanenberg et al. (2002) found that reflectors failed fewer units than activists. There is a consistent finding that students who have a preference towards a reflective learning style perform better than those students with a preference for an active learning style.

With students with a mild preference on the visual / verbal dimension removed from the sample, the correlations between the visual / verbal dimension (using values on an interval scale) and course marks remained at .19. On analysing the data in more detail, it became evident that visual learners obtained lower course marks than verbal learners. Due to the low number of moderate or strong verbal learners (n=3), the results are not statistically significant (p=0.45). However, it is of interest that the average class mark for the moderate and strong visual learners is 49.19%, whereas the average class mark for the moderate and strong verbal learners is 56.67%.

It is important to note that there are many other factors that affect student performance in a course, for example gender, population group, prior knowledge. In the next section the relationship between learning styles and a few demographic factors is examined.

5.4.6 Relationship between learning styles and demographic factors

The data was examined to see if there were any relationships between the learning style preferences and demographic factors such as: gender; population group; type of school attended; whether or not family had studied at university; etcetera. The identified relationships are commented on below.

Gender

There are only fourteen females in the sample group, of these fourteen, ten are sequential learners. That is, 71% of the females are sequential learners compared to 54% for the entire sample. This is depicted in Figure 5.6.

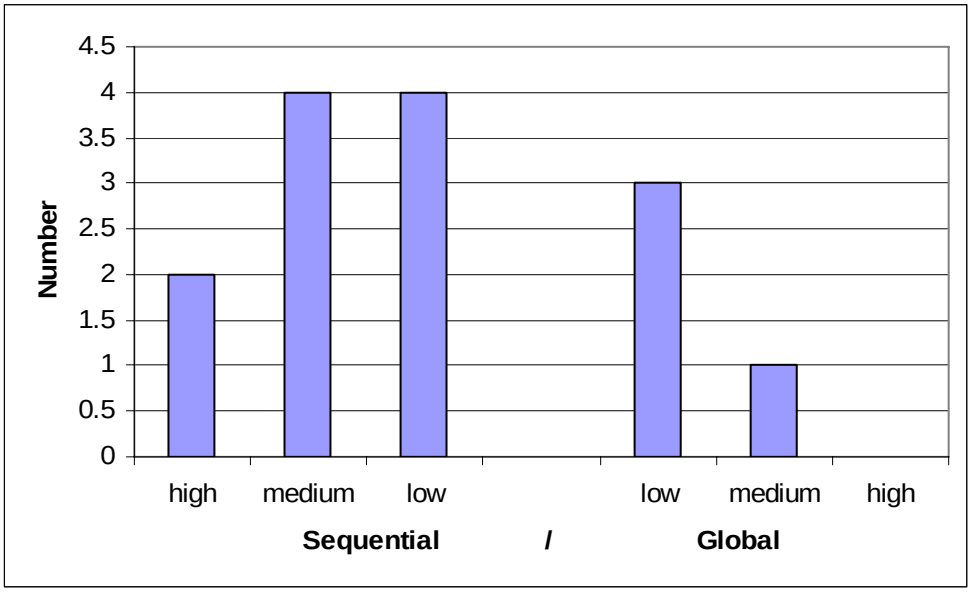

Figure 5.6 Number of female sequential / global learners

As discussed in chapter three there appears to be little consistency in the literature regarding the relationship between learning styles and gender.

Population

In 1987 Claxton and Murrell indicated that there was a most pressing need to learn more about the learning style of minority students, in particular black students. None of the papers I read, including the paper by Sayed (1988) where the population was Wits students, had a large number of black students in the sample data. However, in this study, over 65% of the sample population are black students. Some comparisons between the population groups are summarised below.

Of the 20 white students in the class, 14 are reflective learners. That is, 70% of the white students are reflective learners compared to 61% for the entire sample. What is noteworthy is the number of white students that are moderate or high reflective learners and that no white students are moderate or strong active learners. This is depicted in Figure 5.7.

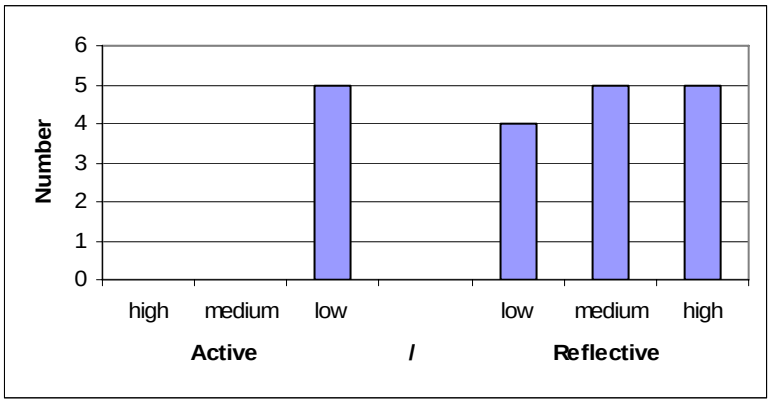

Figure 5.7 Number of white active / reflective learners

There are more reflective black learners than there are active black learners, 38 and 27 respectively. However, the difference in the distribution over the active / reflective dimension between white and black students is evident by comparing figures 5.7 and 5.8.

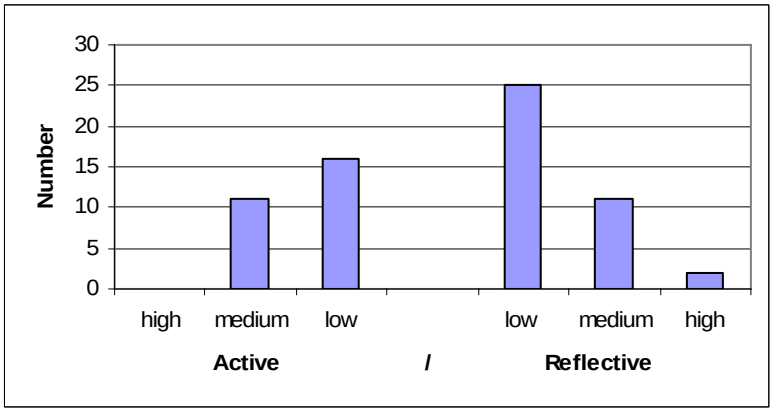

Figure 5.8 Number of black active / reflective learners

White students tend to have a preference towards a reflective learning style (score of 3.85) and black students have no preference for either category (score of 0.71) on the active / reflective dimension. The results are statistically significant (p=0.007).

Although the data could be analysed from a number of additional perspectives, this was not within the scope of the study. The findings presented above will now be summarised and discussed.

5.5 Summary and Discussion

Based on the responses to the ILS the data was analysed from a number of angles. Initially the data was analysed to assess what were the predominant learning style preferences of the sample group across the four learning style dimensions: active / reflective; sensing / intuitive; visual / verbal; sequential / global. Within these dimensions the data was further analysed to understand if the preferences displayed by the students were mild, moderate or strong. The data was then analysed from a number of perspectives to see if there was any relationship between learning style preferences and student success. The results are summarised and discussed below.

What were the predominant learning style preferences of the sample group across the four learning style dimensions?

Comparable with other studies (Felder and Spurlin 2005) on the learning styles of engineering and science students, 81% of the sample group are visual learners. However, 63% of the sample group are reflective learners and this result is different to the findings of other learning style studies reviewed (Felder and Spurlin 2005; Van Zwanenberg et al. 2000; Chen 2003).

I have been unable to explain why the research sample population displays a different preference in the active / reflective dimension to that evident in other studies. Of note is that although twice the number of students are reflective than active, a large number of the reflective and active students have low scores, indicating no strong preference for either category of the dimension.

Within each learning style dimension, did students who favoured one category or another perform better?

Using a nominal scale, no statistically significant differences were found with reference to the learning style preferences of the students and the FAC course mark. However, reflective learners scored higher than active learners; intuitive learners scored higher than sensing learners; verbal learners scored higher than visual learners and sequential learners scored higher than global learners. This pattern is found in other similar studies (Thomas et al. 2002) and is aligned with the belief that the teaching methods of lecturers in the

engineering and science faculty favour the learning styles of those students who are reflective, intuitive, verbal and sequential (Felder 1993).

Using an interval scale, one statistically significant difference was found when students with a mild preference were removed from the sample population. On average active learners obtained lower course marks (45.17%) than reflective learners (55.48%), (p=0.02). However, being a reflective learner did not guarantee good results as some reflective learners obtained poor results.

What are the learning style preferences for particular groups of students?

The top, excelling students are notably more reflective (89% vs 61%) and intuitive (78% vs 40%) than the overall sample. These observations could be accounted for or explained by Felder's (1993) comments that engineering, and probably computer science, instruction favours those students who are reflective and intuitive. However, this is only one explanation for the finding and there could be other valid reasons. For example, white students tend to have a preference towards a reflective learning style and, on average, white students achieved higher FAC course marks than black students.

Compared to the learning style profile of the entire sample group, the borderline / struggling students are notably more sensing (77% vs 57%) and slightly more sequential (65% vs 54%) than the overall sample. The preference for the sensing learning style by borderline /struggling students is opposite to that found for the top, excelling students for the intuitive style. This finding seems plausible as the FAC course is theoretical and requires innovation and abstract thinking, whereas a student who has a preference for a sensing learning style is a concrete thinker who likes to memorise facts and solve problems using well-established methods, which is not a suitable approach to excel in the FAC course.

Was any particular learning style profile successful?

Although there are 16 unique learning style profiles as determined by the four dimensions, more than half (55%) of the entire sample falls within one of four profiles. (A profile is a combination of the four dimensions, for example: verbal, reflective, sensing and sequential.) The average class mark for each profile was compared against the average class mark for the entire sample. Using the two-tail t-test no statistically

significant results were identified and no unique profile was identified that was related to students being successful or unsuccessful.

In the next chapter the learning approaches adopted by students are investigated. This is followed by chapter 7 where the learning styles preferred, and the learning approaches adopted, by students are explored in greater detail by examining the findings from the interviews conducted with a number of students.

6. ANALYSIS OF LEARNING APPROACHES QUESTIONNAIRE RESULTS

6.1 Introduction

In the previous chapter the focus was on the first research question and the results from the learning style instrument were analysed and discussed. In order to start to answer the second research question: "what are the learning approaches used by students studying the FAC course?" and to explore if there are any relationships between learning approaches and student success, this chapter presents the analysis of the data collected from the learning approach instrument administered to the sample group of 99 FAC students. The method used to process and analyse the data is first outlined. This is followed by an analysis of the data using the methodology described by Rollnick et al. (2004). The data is then analysed using a slight modification of the procedure followed by Rollnick et al. (2004). Finally some relationships between learning approach ratings and other factors are explored.

6.2 Data Processing

In Chapter 4, the method used to capture and clean the data from the four parts of the questionnaire was explained. In this section, the data processing specific to the learning approach instrument is described. To recap, an instrument that was constructed by Rollnick et al. (2004) in South Africa with Chemistry students was used. A copy of the instrument is attached in Appendix D. A sample item is shown below in Figure 6.1

I like to be told precisely what to do in FAC tut/lab sessions

A. I agree with this statement because when I present my work I would like it to be what the lecturer wants and not waste time.
B. I agree with this statement because I have to know exactly what I need to do to pass
C. I disagree with this statement because I like to do things on my own and express myself freely.
D. I disagree with this statement because if I am always told what to do I will never learn to solve problems.
X. None of the above expresses my point of view which is ……

Figure 6.1 Sample item from the learning approach instrument

In line with the recommendation of Bennett et al. (2001) each question gave the students the opportunity to respond with an "X" if they did not agree with any of the provided answers. 31 students used this facility. A number of students (18) only used this option once. One student gave an "X" response seven times. A total of 78 "X" responses were made, this equates to only 3.5% of the total 2,178 responses that were made by the students.

Rollnick et al. (2004) had given each fixed response a rating on a scale of 1 to 7, with 7 representing a deep learning approach and 1 a shallow approach. I used these ratings for processing the responses from the FAC students. For the X responses noted above, as well as for the three new, FAC specific, questions explained in chapter 4, a rating of between 1 and 7 had to be assigned to each response. The method followed to do this is outlined in the next section.

6.2.1 Assigning values for responses

For the assigning of the ratings, I followed the method used by Rollnick et al. (2004) for the original questions used in the development of their learning approaches instrument. (Although not referred to as such, this is in essence the Delphic approach where experts are used to collaboratively agree on something). Therefore, for this process, guidance was obtained from Rollnick (2004 – Study Approaches Rubric, attached as Table A3 in Appendix A).

A total of six panel members (FAC research panel) were used to rate the responses for the three new questions as well as the "X" responses explained above. Three of the members on the original panel that developed the rubic were on this FAC research panel. These FAC research panel members were therefore experienced with the technique and provided good consistency across all the ratings. Two of the FAC research panel members were from the School of Computer Science and had a good understanding of appropriate learning approaches for the FAC course. I was the sixth FAC research panel member.

Each panel member gave a rating to each response. Where the difference between highest and lowest rating was 3 or less Rollnick et al. (2004) used the mode of the values. In addition to this the average and median of the ratings was calculated. In many instances these three values were identical and this was therefore the value assigned to the response. Where this

was not the case, aligned with the method used by Rollnick et al. (2004), the mode was the first value of choice. However, I assessed the ratings proposed by the panel for each response and where the mode did not give a correct indication of the values proposed by the experts the median was used. For example, for one of the responses from a student three of the panel proposed a rating of '3' and three of the panel proposed a rating of '1'. In this instance I used the median, which was equivalent to the average, i.e. a '2'. In another example, two of the panel proposed a '7' rating', one of the panel a '6.5', one a '6', and one a '5'. In this instance the mode was 7, the median 6.5 and the average 6. I used the median, i.e. '6.5'. In only one case was the difference between highest and lowest rating proposed by the panel greater than three. In this instance the average, mode and median were all equivalent and the one value was therefore considered an outlier and excluded.

Contrary to the instructions, nine students (9%) indicated more than one response for some of the questions. Seven of the nine students did this for only one or two of the questions. However, one student did this for 6 of the questions and another student for 10 of the questions. A decision was made to average the values of the responses given for a particular question. On further reflection, a better method may have been to use the highest rating of all the responses given for a particular question on the grounds that strategic thinkers would use several approaches, and the response indicating the deepest approach would be the one they perceived themselves capable of. The number of multiple responses (25) was only 1% of the total 2,178 responses that were made by the students, and, as only two students gave multiple answers multiple times the analysis was not redone.

Twenty-one students also left a few questions blank. In total 72 responses, equating to 3.3% of the total responses, were left blank. In these instances the particular questions were excluded from the average rating calculated for the particular student.

In the next section, the procedure used to analyse the data is explained.

6.3 Data analysis

The method used to analyse the data is based on the method used and explained by Bennett et al. (2001) and Rollnick et al. (2004). The exact procedure followed is described below.

1. For each student, an overall average "learning approach rating" (average rating) was calculated from the ratings of their responses to each item on the questionnaire.
2. The students were then ranked in order of their average rating.
3. Approximately the top 20% of the students, in terms of their average rating, were identified. This group is referred to as the group favouring a deep (D) approach to learning. (22 students were identified whose average rating ranged from 5.09 to 5.68)
4. This group (D) of 22 students were then ranked again using their FAC course mark.
5. The top sub-group were referred to as students who had achieved high marks (H) and the bottom group as students who had achieved low marks (L).
    - Four students were identified as following a deep approach and achieving high marks (above 60%). This sub-group were referred to as "DH".
    - Eight students were identified as following a deep approach and achieving low marks (below 45%). This sub-group were referred to as "DL".
6. Steps 3 to 5 were repeated for the bottom 20%. That is, the bottom 20% of the students in terms of their average rating, were identified. This group is referred to as the group favouring a shallow (S) approach to learning. (25 students were identified whose average rating ranged from 2.73 to 3.89)
    - Four students were identified as following a shallow approach and achieving high marks (above 63%). This sub-group were referred to as "SH".
    - Five students were identified as following a shallow approach and achieving low marks (below 45%). This sub-group were referred to as "SL".
7. As one of the aims of the research was to understand the profile of struggling students, an additional group to that considered by Rollnick et al. (2004) was analysed. For each of the "D" and "S" groups, those students who had achieved borderline (B) marks were identified. (It is not necessarily the situation that students who obtained borderline marks were "struggling students" in that these students may not have been working hard and making great efforts. However, for the questionnaire sample it was not possible to ascertain this second aspect of the definition for "struggling students", therefore students whose marks were borderline were used to represent this group.)
    - Ten students were identified as following a deep approach and achieving borderline marks. This sub-group were referred to as "DB".

- Seven students were identified as following a shallow approach and achieving borderline marks. This sub-group were referred to as “SB.

8. For each of the six groups identified above, tally charts were used to produce a list of the responses to each item for the students within each sub-group. The statements for the most frequently selected responses were then used to build up the profile for students with each of the six sub-groups. Only statements that occurred in at least 75% of the sub-group were included in the profile, (except for the “DB” sub-group where 70% was used.) For example, the response pattern to a particular item for the “DL” group was CCCBDCCC. That is, 75% of the “DL” group gave a response of “C”. The statement associated with response “C” in the learning approach instrument was included in the profile of the “DL” group.

The results of the data analysis outlined above are provided and discussed in section 6.4.5 below.

As an alternate to the above approach, the above steps were “reversed”. That is, instead of first ranking the students in order of their average learning approach rating (step 2 above), I first ranked the students in order of their FAC course mark. Then for steps 3 to 8 above, these groups were ranked by their average “learning approach rating”. The results are discussed in section 6.4.6 below.

6.4 Findings

In this section the various findings are summarised. The focus is on the learning approach profiles of the students which are discussed from sections 6.4.2 to 6.4.6. The relationships between the learning approaches adopted by students and FAC course marks are explored in sections 6.4.1 and between the learning approaches adopted by students and other factors in section 6.4.7 to 6.4.9

In this chapter I often use the phrase used by many researchers: “the learning approach **adopted** by students”. This assumes that the learning approach instrument has truly measured the learning approaches followed by the students. I therefore also use the phrase: “students who expressed views **displaying** a deep approach to learning”. This

phrase is theoretically more correct, but I have used the alternate shorter phrase in many instances to ease the reading of the material.

6.4.1 Relationship with FAC course marks

Before drawing up the profiles as outlined above, the data was examined to see if there were any relationships between the learning approaches adopted by students and the marks they obtained for the FAC course. As evidenced in Figure 6.2 no relationship was found between the learning approach rating and course marks. Ironically, from this analysis, if any relationship is present it is a very low negative relationship (r = -0.07), that is students who adopt a shallow learning approach get higher course marks. Contrary to what was generally reported in the literature review, there is no relationship between better grades and a deep learning approach.

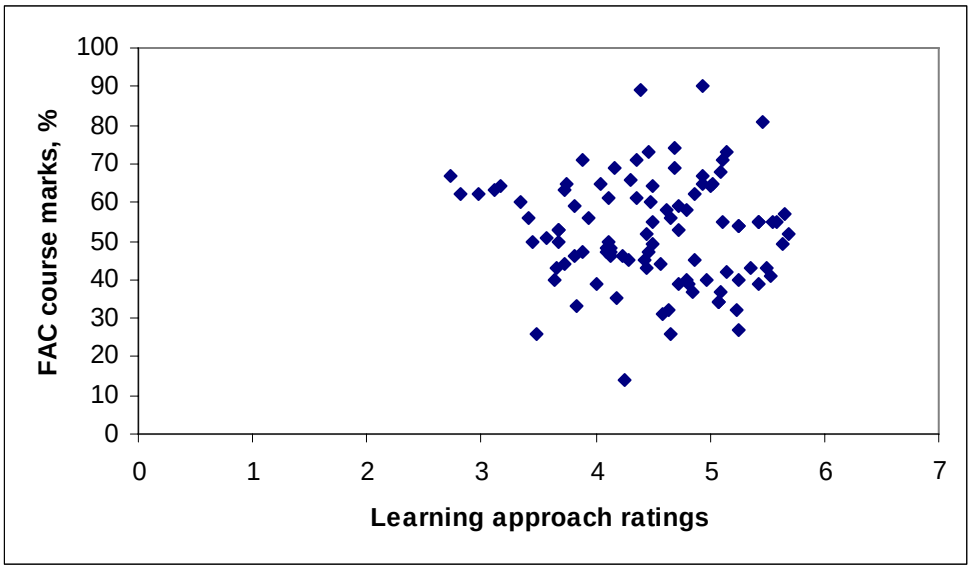

Figure 6.2 Scatter graph of learning approach ratings and FAC course marks

From a slightly different perspective, groups of students according to course marks, (excelling, borderline / struggling, competent, failing), were analysed. The sample size (n) and average learning approach rating for each group is presented in Table 6.1. Again, it is evident that there is no direct relationship between the learning approach rating and the groups of students based on FAC course marks. However, the top nine students in the class do appear to adopt a deep learning approach. Ironically, those students who achieved between 60% and 69%, the competent students, have the lowest average

learning approach rating. The maximum rating computed for a student was 5.68, the minimum 2.72 and the mean was 4.48.

Table 6.1 Comparison of learning approach rating per group of students

Group of students according to FAC class mark	**n**	**Average learning approach rating**
Sample Group	99	4.48
Excelling (course mark > 70%)	9	4.71
Competent (course mark between 60% & 69%)	22	4.10
Borderline / Struggling (course mark between 45% & 55%)	31	4.51
Failing (course mark < 45%)	29	4.68

Relationships between the learning approach rating and other factors such as gender, population and learning styles are discussed in sections 6.4.7 to 6.4.9. The learning approach profiles of the students are described in the next sections.

6.4.2 Commonalities in profiles obtained

Rollnick et al. (2004) found that for a number of questions, a particular option was chosen by more than 50% of the respondents. This was not the situation in the FAC sample group. There was only one question where 50% of the respondents selected the same item. This was the response to question 1 on the meaning of the term learning and this is discussed in the next section below.

6.4.3 The meaning of "learning"

The first question on the questionnaire asked the students to circle the statement that best fitted their view on what the term 'LEARNING' means. 50% of the entire sample replied that learning means "being able to use the information I have acquired". 76% of the students who expressed views displaying a deep approach to learning gave this response, whilst in comparison only 25% of the students who expressed views displaying a shallow approach to learning gave this response. The view of the panel of experts was that response D, "being able to use the information I have acquired", displayed the deepest learning approach with a rating of 6.

6.4.4 Motivation

The second question explored the reason the respondents had for entering higher education. 75% of the students who expressed views displaying a shallow approach to learning replied that "this qualification will enable me to get a good job". In contrast only 29% of the students who expressed views displaying a deep approach to learning gave this response.

The majority (57%) of the students who expressed views displaying a deep approach to learning replied that "I will be able to study subjects in depth, and take interesting courses". This was the response that the panel of experts believed displayed the deepest learning approach, with a rating of 7, for this question.

6.4.5 Profiles

The profiles of the various categories: SL, SH, DL and DH are given in Table 6.2. The percentage given in brackets is the percentage of respondents in this sub-group who gave the particular reply. The two questions discussed above have not been included in the profile.

Table 6.2 Learning Approach Profiles

	Low Marks	**High Marks**
Shallow Approach	SL Group ▪ Gear their studying closely to what seems to be required for tests and exams as passing is most important for their future. (80%) ▪ Like to be told precisely what to do in FAC tut/lab sessions, as they want to know exactly what they need to do to pass. (80%) ▪ Go over the work done in FAC tut/lab sessions because checking is important to get higher marks. (80%)	SH Group ▪ Gear their studying closely to what seems to be required for tests and exams as passing is most important for their future. (100%) ▪ Like to be told precisely what to do in FAC tut/lab sessions, as they want to know exactly what they need to do to pass. (75%) ▪ Wonder if their academic work is worthwhile as even though they work hard, they sometime do not get good marks. (75%) ▪ Find they have to memorise most of what they have to learn, but try to understand first. (75%) ▪ Tend to read little beyond what is required for passing as if they read too much, they lose focus and believe it is best to stick to the facts. (75%)

	Low Marks	High Marks
Deep Approach	DL Group ▪ When studying, they stop from time to time to think about what they are trying to learn because they want to know if what they are learning makes sense. (88%) ▪ Work steadily through the term rather than leaving it to the last minute, as they like to learn and not just pass. (75%) ▪ Like exams that allow them to show that they have thought about the subject for themselves because it tests if they understand their work. (75%) ▪ Do not think it is most important to spend their time learning the information they need to know to pass as learning is about broadening the mind and not just passing. (75%)	DH Group ▪ Question things they hear in class or read in books because questioning helps them to understand (75%) ▪ Do not like teachers who tell them exactly what to put down in notes, as it does not enable them to understand for themselves. (75%) ▪ Read beyond what is required for passing, as learning is not just about passing, but about understanding and application. (100%) ▪ Find FAC relevant because the underlying structure of programming is shown. (75%) ▪ When learning how to do direct proofs, they practice a number of examples because they then develop a method and do not need to learn the proofs off by heart. (75%)

The students in the SL and SH groups have two items in common in their profile. Both of these items place an emphasis on passing, (highlighted in yellow in Table 6.2). It is difficult to see what distinguishes the SH group from the SL group - why does the SH group get high marks (over 60%) and the SL group fail? On one of the questions, 75% of the SH group responded that although they have to memorise the work, they do try and understand it first. This may indicate that this group does aim to get an understanding of the work. This combination of focusing on what needs to be done to pass, a possible indication of a strategic approach, as well as trying to get some understanding of the material may be the reason for this group passing.

Those students who expressed views displaying a deep approach to learning emphasise the importance of understanding the material, (highlighted in blue in Table 6.2). The DL group in particular emphasises that they focus on learning and understanding and not just passing. Given that this group did not pass, even though they expressed views displaying a deep approach, it could be that they are **so** focussed on understanding the material that they do not adopt a strategic enough approach to pass the examination and course. It is interesting to note that the DH group has a common approach to learning direct proofs and that this method is very pragmatic and strategic.

As mentioned earlier, as one of the aims of the research was to understand the profile of struggling / borderline students, an additional group to that considered by Rollnick et al. (2004) was analysed. The results of the "DB" and "SB" sub-groups are summarised in Table 6.3.

Of the five characteristics of struggling / borderline students who expressed views displaying a deep approach to learning, three of the characteristics are the same as those adopted by the DL group. These are the first three items listed in Table 6.3 under the "Deep Approach". The item highlighted in pink may give an indication why these students fail or struggle to pass the FAC course even though they adopt a deep approach. It may be that these students do not adopt a strategic enough approach and do not spend enough time focusing on passing the exam as they are focusing on "broadening their mind". This is a noble objective, but may not be aligned with the need to pass courses.

Table 6.3 Profile of struggling / borderline students

	Struggling / Borderline Students
Shallow Approach (n = 7)	▪ Like books that give clear information that can easily be learned and remembered as it helps to get more marks. (86%)
Deep Approach (n = 10)	▪ When studying, they stop from time to time to think about what they are trying to learn because they want to know if what they are learning makes sense. (70%) ▪ Like exams that allow them to show that they have thought about the subject for themselves because it tests if they understand their work. (70%) ▪ Do not think it is most important to spend their time learning the information they need to know to pass as learning is about broadening the mind and not just passing. (80%) ▪ Do not like tests or exams that need only the material given in class notes as they like challenges and being able to give their opinion and show their understanding. (70%) ▪ Read beyond what is required for passing, as learning is not just about passing, but about understanding and application. (70%)

In the next section, the results obtained from a slightly alternative way to that used by Rollnick et al. (2004), are discussed.

6.4.6 Results from alternative process to determine profiles

As an alternate to the process followed by Rollnick et al. (2004) I first ranked the students in order of their FAC course mark and identified three groups, those with high marks, those with low marks and also borderline / struggling students. Each of these groups were then ranked by their average "learning approach rating". Interesting results were obtained.

I used the code "HD" and "HS" to refer to the sub-groups first sorted by FAC course marks and then learning approach rating. These sub-groups are comparable to the sub-groups "DH" and "SH" discussed above. Likewise I used the codes "LD", "LS", "BD" and "BS".

Even though the sorting was done in a different order, the following results were obtained:

- Between the sub-groups "LD" and "DL" four out of a sample of seven and eight respectively were identical. The overlap is shown pictorially in Figure 6.3 where the same students within each sub-group are highlighted in blue. Of interest is that the response trends identified in sub-group "LD" were very similar to those identified in sub-group "DL"

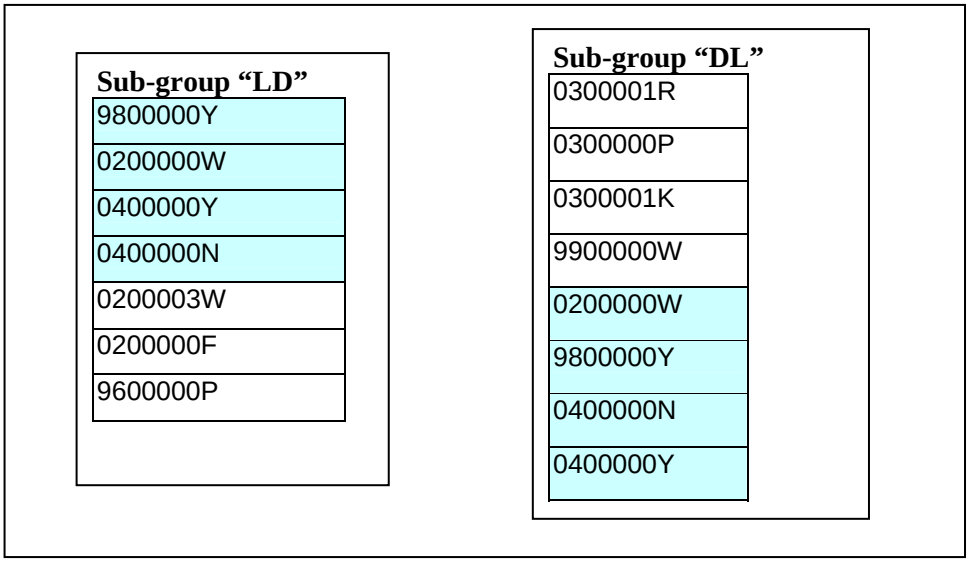

Figure 6.3 Overlap of sample between two sub-groups

- Between the sub-groups "LS" and "SL" three out of a sample of six and five respectively were identical. However, there were differences in the response trends.

- The students falling into the sub-groups “HD” and “DH” were identical. There was one different sample between the sub-groups “HS” and “SH”.
- For the borderline students, “BD” and “BS” and “DB” and “SB” the students falling into the related sub-groups were identical.

The above results demonstrate that there is fairly good reliability in the process followed to construct the learning approach profiles. The use of two slightly different procedures could be viewed as two researchers processing the same data in slightly different ways and obtaining very similar results. On the other-hand the slightly different results also illustrate the importance of documenting the methodology followed very carefully so that other researchers can repeat it.

6.4.7 Relationship with demographics

The data was examined to see if there were any relationships between the average learning approach rating with demographic factors such as: gender, population group, whether or not family had studied at university, etcetera. The identified relationships are commented on below.

Gender

There is a relationship between females and the learning approach rating and males and the learning approach rating. On analysing the data it is evident that females tend to adopt more of a surface approach and males more of a deep approach to learning. The differences are evident in Table 6.4. A two-tailed t-test indicated a statistically significant difference between the average learning approach ratings for the two groups (p=0.0095). However, there are few females in the class, so the results may not be reliable. No relationship between gender and FAC course mark was found.

Table 6.4 Learning approach rating by gender

Gender	n	Learning Approach rating
Sample	99	4.48
Female	14	3.93
Male	85	4.57

In the research carried out by Regan and Regan (1995) they observed that females were higher than males on achieving (strategic) strategies. Strategic strategies were not

explicitly measured by the learning approach questionnaire that I used. Regan and Regan (1995, pg 7) also report on other studies and comment that "with respect to gender differences amongst university students' approaches to studying and learning, inconsistent results have emerged". Regan and Regan (1995) report that often an absence of gender differences have been reported, but that some researchers have reported that in science disciplines females are more likely to use a deep approach and males a surface approach. The results of my research were opposite to this, but this could be as a result of the small sample size for females.

Population group

There is a relationship between black students and the learning approach rating. The average learning approach rating for black students is 4.61 and for non-black students it is 4.24. That is black students tend to adopt more of a deep approach than the rest of the students. The differences are evident in Table 6.5 A two-tailed t-test indicates a statistically significant difference between the two groups (p=0.0154).

Table 6.5 Learning approach rating by population

Population	n	Learning Approach rating
Sample	99	4.48
Black	65	4.61
Non-black	34	4.24

6.4.8 Relationship with learning styles

There are some interesting relationships between learning styles and learning approach ratings. There is a low positive relationship between the learning approach rating and intuitive learning style (r = 0.28), and the learning approach rating and the global learning style (r = 0.33). That is the more intuitive or global thinker a student is the deeper the approach the student adopts to learning.

6.4.9 FAC specific learning approach questions

A final relationship worth commenting on is that three new questions were specifically written for the FAC sample. The average learning approach rating for these three questions has a low positive correlation with the course mark (r = 0.23) and with the class mark (r = .029). (The class mark excludes the examination result). This is a very small

sample, but it may indicate that more positive correlations would be obtained if all the questions had been specifically written and piloted for the specific population. This is aligned with some of the comments made by Booth (1992), Entwistle (1988) and Case and Marshall (2003) regarding the context sensitivity of the learning approaches.

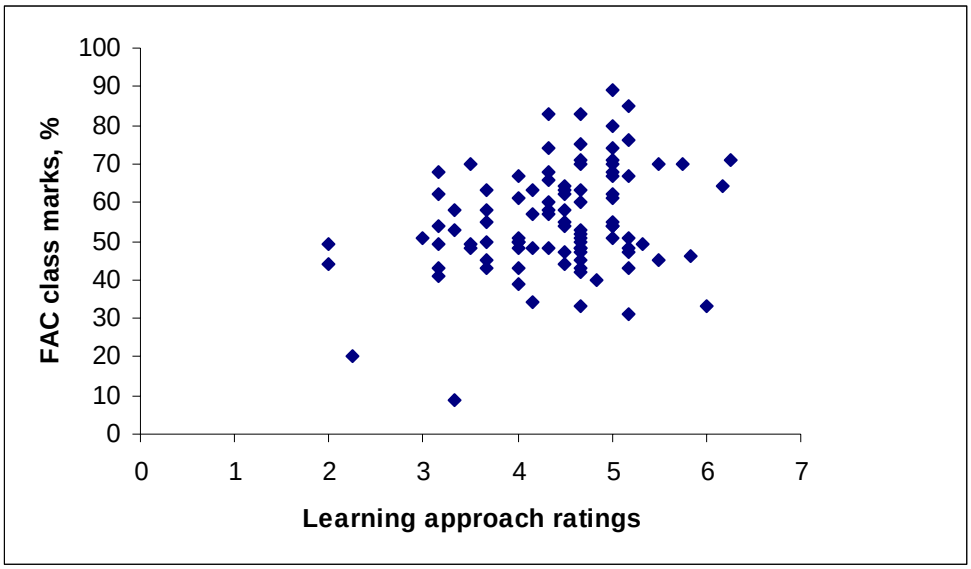

Figure 6.4 Scatter graph of learning approach ratings for three FAC specific questions and FAC class marks

6.5 Summary

Contrary to earlier research findings no relationship was evident between the average learning approach ratings of students and the FAC course mark. As summarised in the literature review there could be a number of reason for this. This will be discussed in chapter 8. Statistically significant differences were found in the average learning approach ratings of blacks compared to non-blacks, and females compared to males. Black students tend to adopt more of a deep approach than the rest of the students. Females tend to adopt more of a surface approach and males more of a deep approach to learning. From a learning style perspective, the more intuitive or global thinker a student is, the deeper the approach the student tends to adopt to learning

The learning approach profiles reveal some expected and interesting characteristics of the various groups. Students in the SL and SH (surface approach) groups emphasise the importance of **passing**, whereas those students who expressed views displaying a deep

approach to learning emphasise the importance of **understanding** the material. One selected item gave an indication of why students fail or struggle to pass the FAC course even though they adopt a deep approach. These students "do not think it is most important to spend their time learning the information they need to know to pass as learning is about broadening the mind and not just passing". It may be that these students do not adopt a strategic enough approach and do not spend enough time focusing on passing the exam as they are focusing on "broadening their mind". This is a splendid objective, but may not be aligned with the need to pass courses.

Determining learning approach profiles using a slightly modified procedure to that followed by Rollnick et al. (2004) demonstrated that there is fairly good reliability in the process followed to construct the learning approach profiles. A final relationship worth commenting on is that there was a low positive correlation between the average learning approach rating for the three FAC specific questions and the FAC class mark.

In the next chapter the learning approaches adopted by students are explored in more detail by examining the findings of the interviews.

7. ANALYSIS OF STUDENT INTERVIEWS

7.1 Introduction

The other analysis chapters focussed on the data gathered through the survey. This chapter is the result of the ethnographic design where the focus is to provide an in-depth description of the learning approaches used by students studying the FAC course. The goal is to paint as vivid and accurate a picture as possible so that others can understand the nuances of the particular situation. Semi-structured interviewing was used and eight students were interviewed to find out how they approached their studies. The interviews were also used as a means to validate some of the information obtained from the questionnaire.

First the methodology followed to analyse and interpret the interviews, including the theoretical framework, is described. This is followed by an exposé of the results and findings largely arranged according to the sections covered in the interview schedule: student background information; student preferences and understanding of Computer Science; learning styles; learning approaches; other emergent themes; why students believe they are not performing as well as they could and advice for "improving" FAC. In the last sections the results from the learning approach questionnaire are compared to the findings from the interviews and the findings from the interviews are summarised and discussed.

7.2 Analysis and Interpretation of Interviews

In order to interpret the data obtained from the interviews, the qualitative method of multiple readings recommended by Denzin and Lincoln (1998) and Marshall and Case (2003) was followed. The overall approach was to first read each interview a number of times, looking for different aspects on each reading and making notes against the individual student's responses. This included the identification of themes. As a second step, each theme across all the interviews was reviewed as a unit and the results synthesised. This followed the general approach recommended by Mouton (2001) of first analysing and then interpreting and synthesising the data. A diagram depicting the approach used is provided in Figure 7.1. Each step is described in some greater detail in the following sections.

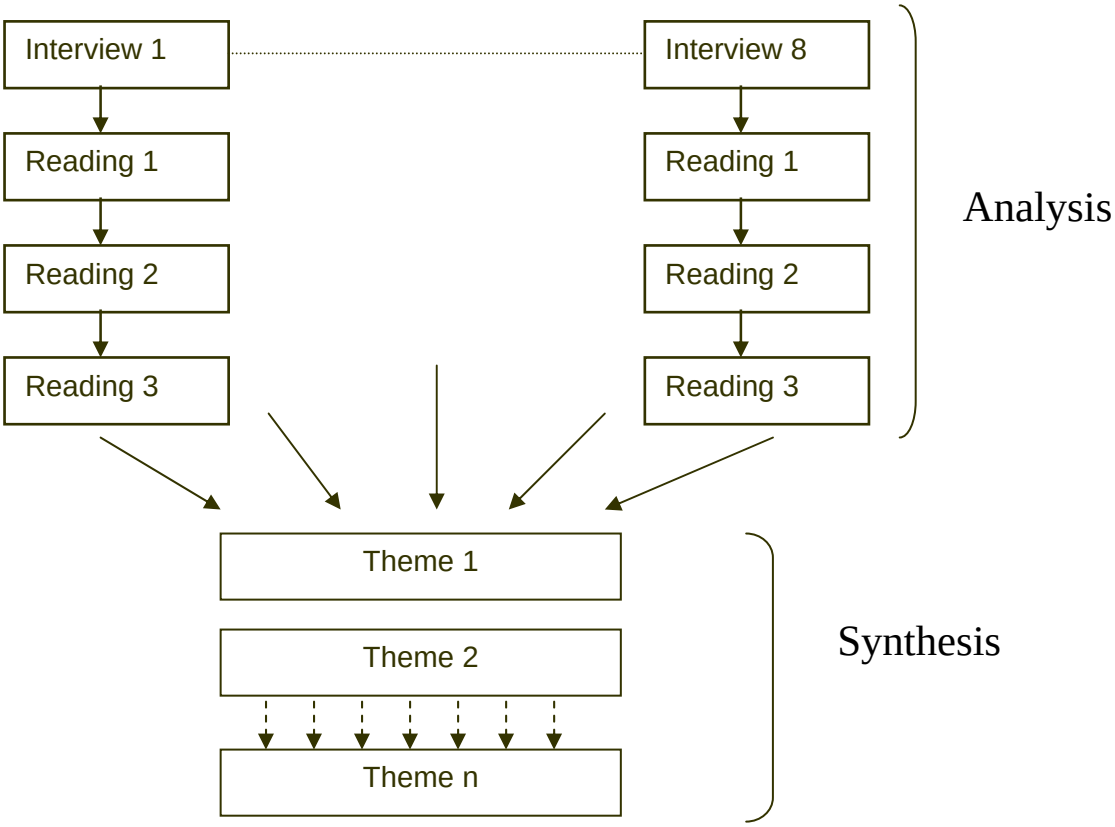

Figure 7.1 The approach used to analyse and synthesise the interview data

This approach explained above also follows the recommendations of Booth. Booth (1992, pg 62) describes in great detail how to thoroughly study and analyse the data, for example, "If the material is in the form of interviews, they will be read one by one in their entirety, and they will be read side by side, switching from one to the other".

7.2.1 The analysis of each interview

An example of an analysed interview is attached as Appendix J. According to Mouton (2001, pg 108) "Analysis involves 'breaking up' the data into manageable themes, patterns, trend and relationships." On the first reading of each interview, notes were made next to the student's responses, summarising the essence of what the student had communicated. In the example below my comments are indicated in bold type:

> *"I like working with computers, I want to be a designer and an inventor yeah so I think it's a right course for me."* **Student has a clear vision of what he wants to do later in life.**

> *"You know the base cases and you actually get marks from those base:"* **Student commenting on how to get marks.**

On a second reading, I particularly looked for and noted links and relationships to other parts of the interview so that the entire interview was considered and not just paragraphs in isolation, for example:

> *"I like working with computers, I want to be a designer and an inventor yeah so I think it's a right course for me."* **Student has a clear vision of what he wants to do later in life – student expanded on this aspect later in the interview. Student also noted later that he does not like Engineering – seems a bit of a contradiction if he wants to be an inventor.**

On the third reading, I identified each comment according to a colour code, for example, I highlighted my note in grey for the theme of "Understanding of what Computer Science is about and / or what they want to do when they have completed University"

> *"I like working with computers, I want to be a designer and an inventor yeah so I think it's a right course for me."* **Student has a clear vision of what he wants to do later in life – student expanded on this aspect later in the interview. Student also noted later that he does not like Engineering – seems a bit of a contradiction if he wants to be an inventor.**

On each reading I also examined the responses according to the two theoretical frameworks used in the study, learning styles and learning approaches.

Learning approach theoretical frameworks

Taking account of the theory on learning approaches, on each reading I attempted to comment on whether I considered a response from a student to indicate if the student was taking a surface, deep or strategic approach to learning FAC, for example:

> *"Well I take my notes from the lecture and I try to get books from the library and I think the notes are not, they don't have much information so I have to fetch some computer books yeah*." **Student tries to get additional information - indicates a deep approach. Takes books out of the library and makes the effort to do this, even though not easy to find appropriate books - indicates a deep approach. Later find out that he also does this because the lecturer keeps telling the students that they need to get books from the library – could be indicating a surface approach.**

Mouton (2001, pg 110) notes that a source of error in the analysis and interpretation phase is to draw "inferences from the data that are not supported by the data". Therefore in order to be as consistent as possible and thereby improving the rigour, reliability and validity of the results, when deciding if a comment indicated a surface, deep or strategic

approach to learning, I referred to a model provided by, Entwistle (Entwistle in Schmeck, 1998). This model is Figure A1 in Appendix A. I also referred to a table provided by Biggs (1987) summarising the association between a student's learning approach, motive and learning strategy. This is Table A2 in Appendix A. To classify the student's motive or educational orientation, a table developed by Entwistle (Entwistle in Schmeck, 1998) was used. This is Table A1 in appendix A.

Learning style theoretical framework

When analysing the learning style preference used by the student I referred to the Felder-Silverman model described in chapter 3.

It is worth noting that in the interviews, I showed each student where the results of the ILS had placed them on the diagram below (Figure 7.2) and asked them if they thought it was a true reflection and if they had any comments.

Definitions	DIMENSIONS		Definitions
Do it	*Active*	*Reflective*	Think about it
Learn facts	*Sensing*	*Intuitive*	Learn concepts
Requires Pictures	*Visual*	*Verbal*	Require reading or lecture
Step by step	*Sequential*	*Global*	Big picture

Figure 7.2 Learning style model used in the interviews

As students tend to agree with the interviewer, the results may have been more robust if I had asked the students to say where they believed they were on the dimension of each category rather than asking them if they agreed with the result of the ILS. However, this approach of asking the students if they agreed with the result was taken due to Felder and Solomon (2004a) noting that "if someone **does not agree** with the ILS assessment of his or her preferences, trust that individual's judgement over the instruments results." This approach of seeing if the **student agreed** with the result was followed literally.

In spite of the above, I believe the results obtained in the interview are valid as on three occasions a student did disagree with the preference computed by the ILS, showing that

they did not just agree with what was given to them. In addition, remarks made during the interview when discussing other topics often confirmed the student's learning style

Even though the theoretical frameworks and models were referred to, deciding if a particular response from a student displayed a surface, deep or strategic learning approach was not an easy task and it became evident that more than one interpretation could be made depending on how the response was understood. According to advice from Schumacher and McMillan (1993) to further validate the classifications, the analysis was reviewed by two people and adjustments were made where required. This assisted with the next stage that was to synthesise and interpret the data.

7.2.2 Interpretating and synthesising the interviews

The next step was interpretation which "involves the synthesis of one's data into larger coherent wholes" (Mouton 2001, pg 109). As the interview schedule was semi-structured, the approach adopted here was to examine each section of the interview across all the interviews, as well as picking up any relevant items for the theme from other sections of the interview. This was facilitated through the colour coding described above.

In the next section, the results and findings from the analysis and synthesis of the interview data are presented.

7.3 Results of Interview Analysis

The results of the interview analysis have largely been arranged according to the sections covered in the interview schedule. A copy of the interview schedule is attached as Appendix G.

1. Student background information (section 7.3.1)
2. Student preferences and understanding of what Computer Science involves (section 7.3.2)
3. Learning styles (section 7.3.3)
4. Learning approaches (section 7.3.4)
5. Other emergent themes (section 7.3.5)
6. Why students believe they are not performing as well as they could and advice for "improving" FAC (section 7.3.6)

Although the write-up has been done this way for ease of reading, the interviews were analysed as a whole and often comments made by the students in one section of the interview provided relevant input for another section. For example, students' responses on which course they liked the most or least often provided insight into their learning approach. This was then discussed under the learning approach section of the write-up.

7.3.1 Student background information

Background questions were asked for three primary reasons. Firstly, the interview started with easy questions to help put the students at ease, secondly the answers given in the questionnaire were verified, and lastly in order to understand the interview sample in greater depth than that provided by the answers to the questionnaire. According to Mouton (2001, pg 124) "a discussion of the sample and its characteristics is essential in order to understand the nature of the findings". The demographics of the interviewed sample are provided in Tables 7.1 and 7.2

Table 7.1 Demographics of interviewed sample

	Pseudo -nym	**Pop ***	**Age**	**Gender**	**Home Language**	**School Type ****	**Matric Maths mark**	**FAC course mark**
Excelling	Joseph	W	18	Male	English	P	100%	90%
	Duncan	W	18	Male	English	G	93%	69%
Competent	Gill	W	19	Female	English	G	86%	62%
	Richard	W	18	Male	English	G	85%	65%
Struggling	Kabelo	B	18	Male	Tsonga	G	79%	55%
	James	B	19	Male	Siswati	G	74%	52%
	Maria	B	17	Female	Setswana	G	69%	53%
	Lindiwe	B	20	Female	Setswana	P	+	44%

* Pop = Population Group; W = White; B = Black.

** The question asked was: "How would you describe your school (government, private, inner city, township, rural)"; P = Private; G = Government

\+ Final mathematics mark unknown due to Botswana private school system.

Table 7.2 Parents' occupation of interviewed sample

	Pseudonym	**Family studied ***	**Parent 1 Occupation**	**Parent 2 Occupation**
Excelling	Joseph	Yes	Neurologist	Public relations
	Duncan	Yes	Accountant	Jeweller
Competent	Gill	Yes	Fitter & Turner	Nursing Sister
	Richard	No	Manager	Teacher
Struggling	Kabelo	No	Teacher	
	James	No	Messenger	
	Maria	No	Teacher	
	Lindiwe	Yes	Teacher	

* The question posed was: "Have your parents or any of your immediate family studied at University."

The students interviewed were classified as excelling, competent or struggling. The classifications were based on FAC class marks, as at the time of the classification the exam results were not available to compute the overall FAC course mark. The class mark was computed from the three class tests. The selection of the students to be interviewed was described in chapter 4. The characteristics of the three groups according to FAC marks are outlined below:

- The two **excelling** students obtained a first for their class mark. One of the students classified as excelling for the interviews, Duncan, obtained 69% for his overall FAC course mark. This student was therefore not included as an excelling student in the analysis carried out in the previous chapters, but has been retained as an excelling student in this chapter as he fitted the initial classification of obtaining a high mark for the FAC class mark (Duncan achieved 82% for his FAC class mark).
- The two **competent** students achieved an upper second for their class mark; coincidently both achieved 70% for their class mark. The two competent students achieved greater than 60% for the FAC course mark.
- The four **struggling** students obtained 60% or lower for their class mark and had failed one of the three class tests. The four struggling students achieved less than or equal to 55% for the FAC course mark. Of note is that all the students interviewed, except Lindiwe, passed the FAC course.

Of interest are the matriculation mathematics marks of all the interviewed students. A good mathematics mark is part of the selection criteria for acceptance into Computer Science I. It is evident that even the students classified as struggling achieved very good mathematics marks at school. As the last column of Table 7.1 I have inserted the FAC

course mark. It shows that according to final course mark achieved the classification of the students into excelling, competent and struggling was satisfactory, although the course mark of the one excelling student was not as high as expected.

7.3.2 Student preferences and understanding of what Computer Science involves

This section was principally included in the interview schedule to help ease the student into the interview with topics that were easy for them to answer and discuss. However, greater value than had been anticipated was gathered from the student responses. The students' responses to a number of questions are therefore summarised below:

- What courses do the students like the most and least?
- Why did students select Computer Science to study?
- What do students want to do once they leave University?
- What did students think they would study in Computer Science?

What courses do the students like the most and least?

Students were first asked what course they liked the most and why, and then what course they liked the least and why. The responses are summarised in Table 7.3

Table 7.3 Courses liked and disliked by interviewed students

	Student	**Course liked the most**	**Course liked the Least**
Excelling	Joseph	Applied Mathematics	None
	Duncan	Applied Mathematics	Mathematics
Competent	Gill	Sign Language and Mathematics	Computer Science
	Richard	Economics and Applied Mathematics	Mathematics
Struggling	Kabelo	Computer Science	Economics
	James	Computer Science	Chemistry
	Maria	Computer Science	Economics
	Lindiwe	Computer Science	Business Accounting

Ironically the four students who were struggling with FAC replied that Computer Science was their favourite course. Whereas the excelling and competent students did not respond that Computer Science was their favourite course. This raised the question of whether the struggling students were struggling in all their other courses or whether the struggling students were trying to give the response they thought the interviewer was looking for. It

was ascertained that two of the struggling students obtained fairly good marks in some of their other courses. When students responded that Computer Science was their favourite course, the interviewer commented that the student did **not** need to say that Computer Science was their favourite. In all instances the students reconfirmed their answer, but it was not possible to verify that this was their genuine view.

Interviewer: Which course do you like the most?
Kabelo: Obviously Computer Science (2;27)
Interviewer: Do you? You don't have to say that?
Kabelo No I love it (2;31)

When the interviewer tried to establish why the struggling students said they liked Computer Science the students seemed to find it difficult to provide their reasons, sometimes providing circular responses.

Lindiwe: Because I like computers. (2;45)
James: My interest are in Computers, that's why I chose Computer Science this year, the other ones are just for the first year BSc degree. (2;24)
Kabelo: Because I want to major in it (2;39)
Maria: I like to major in Computer Science. (2;37)

The answers were probed further when trying to establish why the students chose to study computer science. This is discussed in sections below.

Conversely, the excelling students and competent students were able to provide some deeper reasons for why courses were their favourites. Both of the excelling students noted that Applied Mathematics was their favourite course. Joseph highlighted that Applied Mathematics was his favourite course because most of the material and content was new. Duncan responded that he saw relevance in the course.

Interviewer: Which course do you like the most of those?
Duncan: Em, Probably Applied Maths. (1;22)
Interviewer: And why do you like that the most?
Duncan: Just because I see, you know, where it is going, the applications like chaos theory and so on, and wait in eager anticipation until for when we get to the actual applications. (1;26)

Richard noted that he liked Economics because it was the easiest, but he also liked Applied Mathematics because it was interesting. Gill responded that she liked Sign Language and Mathematics the best. Gill's responses indicated that she had a deep interest and enjoyment in Mathematics and received personal satisfaction from studying it.

Gill: I think, someone said to me, the other day, that, if you are doing something that energizes you, then that is what you should be doing, but if you do something that makes you tired then its not what you should be doing, and when I do maths, and I get a problem that I don't know how to do and I do it

then its not like I'm ugh I can't believe its over its like oh yeah now I've got more energy to carry on. (2;33)

The reasons the students gave for **not liking** particular courses were varied. Duncan, an excelling student, noted that he disliked the course where he had done the work before and was therefore bored.

Interviewer: *Which course do you like the least and why.*
Duncan: *Maths, ironically – I am really interested in maths, basically studied most of what we are doing this year, already last year – so it is boring. I did additional maths and maths in my spare time. (1;32)*

In a similar vein, Kabelo, a struggling student, said he did not like a course because it was not challenging enough.

Interviewer: *Which course do you like the least?*
Kabelo: *Economics? (3;11)*
Interviewer: *And why?*
Kabelo: *Well its, it doesn't require reasoning you know, you just have to read the text and just try the tests, so I want courses to be challenging in which you have to think, like Computer Science. (3;15)*

Quotes from students highlighting the various reasons they gave for not liking a course are provided below:

Maria: *Economics is theory and I don't like theory, I like working with figures.(3;24)*
Lindiwe: *Sometimes I can't grasp what we are supposed to do.(3;21)*
James: *No Chemistry, just takes a lot of time. (3;18)*
Richard: *"I see the point of it* (maths) *but its basically facts, …. It just straight forward study, and its hard work. (3;5)*
Gill: *Well last term it was Computational and Applied Maths, but now its well, Computer Science, I don't know anything about computers and I don't want to. When I chose my subject I had to choose between physics and computers and I just thought computers will probably open more doors if I finish studying it, but its not, programming is not my thing. [laughs]. (3:4)*

Why did students select Computer Science to study?

Students were asked why they had chosen to study Computer Science. A summary of their responses is provided in Table 7.4. It is evident that there are wide ranges of reasons why students decide to study Computer Science, from interest to profitable careers. Sanders and Mueller (2000, pg 227) observe that "due to the perception of good careers in information technology an increasing number of students seemed to be registering" for computer science. Lindiwe's comment fully supports this view:

Lindiwe: *Basically, besides the money, back home its one of the few jobs that are not congested. (3;27)*

Table 7.4 Reasons interviewed students chose to study Computer Science

	Student	Major	Reason
Excelling	Joseph	Yes	Wants to design Computer Games
	Duncan	No	Interest (in programming, networking, etc)
Competent	Gill	No	Had to choose between Computer Science and Physics and thought Computer Science would open more doors than Physics.
	Richard	Yes	Interested in computers, particularly "proper" programming
Struggling	Kabelo	Yes	Has a bursary from Telkom (South African telephone company) and had to choose between Engineering and Computer Science and did not like Engineering.
	James	Yes	Interest in computers
	Maria	Yes	Does not like working with people, likes working with Computers
	Lindiwe	Yes	Money – available jobs

A related question was what students want to do when they finish University and what they want to do with Computer Science. This is looked at next.

What do students want to do once they leave University?

In the interview schedule there was a question regarding what the students thought they would do with Computer Science once they had completed their degree. The question was not always phrased in exactly the same manner as some students volunteered the information earlier in the discussion. Table 7.5 summarises the various responses.

Table 7.5 What students want to do when they finish university

	Student	Future plans
Excelling	Joseph	Design Computer Games
	Duncan	*Question not asked in the pilot interview*
Competent	Gill	Teach the deaf mathematics. Can also teach Computer Science
	Richard	Don't know
Struggling	Kabelo	To be a designer and inventor, to have his own company. To first work at Telkom using his Computer skills as has a bursary from Telkom
	James	Design programs
	Maria	Be a programmer
	Lindiwe	Don't know

It is interesting to note that what the excelling student, Joseph, wants to do when he leaves university corresponds directly with why he is studying Computer Science. As

discussed below, this student was also the only student who had a clear understanding of what he would be studying in Computer Science. Two students do not know what they want to do on leaving university and two (or three if one considers designing computer games as having an element of programming) want to write programs when they finish university. The topic of programming is discussed further below.

What did students think they would learn in Computer Science?

Students were asked if the Computer Science course was what they thought it would be. The students were then asked to clarify what they thought they would study in Computer Science. Their responses are summarised in Table 7.6.

Table 7.6 What students thought they would study in Computer Science

	Student	**CS = what student thought it would be**	**What they thought they would study in Computer Science**
Excelling	Joseph	Yes	Note: Joseph visited the university in 2003 with his parents to find out what would be taught in Computer Science.
	Duncan	No	Writing programs, Computer Science more mathematical than he thought it would be.
Competent	Gill	No	Not sure – "maths on computer"
	Richard	A hesitant Yes	Programming, memory design, etc
Struggling	Kabelo	Yes – some of the things	Designing circuits, proofs, etc
	James	Yes	Programming & computer languages
	Maria	No	Operational aspects – refer to quotes below
	Lindiwe	No – kind of	Programming: HTML, Java (Internet programming languages)

It is evident that many students are not studying what they thought they would be. These responses support the views of Sanders and Mueller (2000) that some students register for Computer Science to learn about computers and programming and many students are not aware of what they will study in Computer Science. Sanders and Mueller (2000, pg 227) remarked: "these students had little idea of the nature of computer science and were registering to gain computing or at best programming skills. These students were discovering that the course was not what they expected".

Programming is a common item raised by a number of students, from excelling students to struggling students. Some of the students' comments on programming are provided below:

Duncan: *I did not actually realise it (Computer Science) would be that mathematical – which is pretty nice. I thought it would be mostly sitting behind a computer like writing programs and so on. (2;14)*
Richard: *I can't wait to start programming, proper programming, because I enjoy that. (3;29)*
Maria: *I want to be a programmer. (4;15)*

Lindiwe: *I thought we would be studying…. okay we will be taught about stuff like HTML* (HTML – Hyper Text Markup Language, is used for creating web pages and is a form of programming). (4;1)
Lindiwe: *I thought we were going to use, [xxx], Java or something.* [Java is a commercial programming language] (4;12)

Interviewer: *What do you want to do with computers once you've completed your degree?*
James: *Design my programs. (2;35)*
Interviewer: *And are you studying in Computer Science what you thought you would?*
James: *Yes*
Interviewer: *What did you think you would be studying when you did Computer Science?*
James: *Studying programming and computer languages. (3;10)*

James responds that he is studying what he thought he would in Computer Science, but he then says that he thought he would study programming and computer languages that are only covered to a small extent in first year Computer Science. This appears contradictory, but unfortunately I did not probe further in the interview. It could be that James was referring to the limited programming done during the tutorial sessions.

Most students believed that they would do more programming than they are in Computer Science, however, Gill had a contrary view to this.

Interviewer: *Are you studying in computers what you thought you would study?*
Gill *No, when we came they gave us this sheet that said, we must try and do this before our first lecture, it was something about boxes and putting them together and I don't know what it was, and that was really fun but then it was, then I found out its all about programming, I didn't know we had to program and circuits and all these funny things. (3;36)*

Maria does not refer to programming, but she does note that she is not studying what she thought she would in Computer Science. Maria thought she would learn more about the operational components of a computer.

Maria: *Sometimes I never thought that I'll learn stuff like graph theory, I thought like maybe we're going to learn like Computers only. (4;24)*
Interviewer: *Can I get an understanding of what you mean by looking at computers?*
Maria: *Getting to know how a computer was made, and the different keys on the keyboard, how, yeah, that's how do they work, and how are they made and what happened, why did they make them. (4;32)*

Although a number of students are discovering that they are not studying what they thought they would in Computer Science, the objectives of Sanders and Muller (2000) namely that "we felt that our curriculum should be structured in such a way that these mistaken perceptions were highlighted as early as possible in the students' career" are being met. However, Baldwin (1990) notes many students expect computer science to be about programming and that this conflict in expectations needs to be managed.

This section raises a number of questions, for example: Should programming be covered in a first year computer science course? How can students be better informed on what material is covered in Computer Science? However, this is not the scope of this research project and the question here is rather whether any relationships are apparent between the perceptions that students have about Computer Science and students' learning approach and / or learning style. For example, a student's expectation of what will be covered in a course could affect their motivation, which in turn could influence their learning approach. As highlighted by Entwistle (1998) and Biggs (1988) students are more inclined to have a deep approach to learning if they have an interest in the subject matter or if the subject matter has vocational relevance (Entwistle 1998). Some of these aspects will be explored further in section 7.3.4. In the next section the learning styles of the students interviewed are briefly looked at.

7.3.3 Learning styles

The ILS was administered to over 100 students to assess their preference for the categories of the Felder-Silverman learning style model. These results have been summarised in chapter 5. The objective in the interview was to ascertain if the particular students interviewed agreed with the results of the ILS.

In Table 7.7 the students' views of their learning style is provided for each of the learning style dimensions. If the student is in agreement with the results of the ILS the learning style category is highlighted in green. If the student is not in agreement with the results of the ILS the learning style category is highlighted in red. The numbers indicate the score from the ILS: the higher the number the stronger the student's preference for that dimension of the category.

Table 7.7 Views of interviewed students on their learning style

	Student	**Active / Reflective**	**Sensing / Intuitive**	**Visual / Verbal**	**Sequential / Global**
Excelling	Joseph	Reflective 7	Intuitive 7	Visual 3 Believes he is fairly verbal	Global 7
	Duncan	Reflective 1	Sensing 1	Visual 7	Global 3
Competent	Gill	Reflective 7	Sensing 3	Visual 9	Sequential 5
	Richard	Active 1	Sensing 3 Believes he is more intuitive than sensing	Visual 7	Global 3
Struggling	Kabelo	Reflective 5 Likes to “do”	Sensing 1	Visual 3	Global 3
	James	Active 3	Intuitive 1	Visual 5	Sequential 5
	Maria	Active 7	Sensing 3	Visual 1	Sequential 5
	Lindiwe	Reflective 5	Sensing 4	Visual 7	Sequential 1

It can be seen from Table 7.7 that students generally agreed with the assessment from the ILS. This provided a good validation of the instrument. The different views expressed by Joseph and Richard are not of concern as they were both fairly well balanced on the dimension that they disagreed with.

Kabelo said he was active rather than reflective, as he likes to “do” things, for example designing. In chapter 5 it was highlighted that there was an unusual high number of reflective students in the sample population compared to other studies. This could indicate that, for the particular population, the ILS did not correctly determine the category on the active / reflective dimension. However, there is also the possibility that the differences between reflective and active were not explained sufficiently by the interviewer, as although Kabelo does like to do things, it was evident from some of his responses that he liked to work alone, for example:

Kabelo: so I like reading on my own, that’s where I like understand. (7;29)

The interviewed students were asked if they had any comments on each dimension. The examples below show that some students had a good understanding of their learning style.

Active / Reflective

Gill confirmed that she is generally reflective as she likes to think about things and prefers not to work in a group. Gill's comments are very interesting as they illustrate that learning styles can be connected to the subject matter. Gill is not interested in group work if she knows a topic as it slows her down, however she is happy to do group work in a topic she is battling with.

> *Gill:* *I like thinking about it, but I don't really enjoy group work, I don't. I like group work when it's a difficult topic and I don't know what's going on, but that's probably selfish, because then I don't want to, if I don't understand something then I don't mind being in a group because I've got nothing to lose. Whereas if I do know what's going on then I'd rather just work by myself because then I don't want other people, who are stupid, to ask me what's* x+2x *or something. So in Computer Science I don't mind working in a group but maths I do [laughs]. (5;10)*

James agreed that he is more active than reflective and commented a few times that he likes to work in groups and to contact friends for assistance. Felder and Solomon (2004b, pg 1) note that "active learners tend to like group work."

> *James:* *the other one (test) I failed, because I was studying alone, then the third one (test) for sure I hope I passed because I was doing it in the group so I've learned many things there. (3;44)*
>
> *Interviewer* *Okay, and how do you check if it (the answer) is correct or not?*
> *James* *whew, I'll check by contacting my friend. (5;29)*

Lindiwe agreed that she is fairly reflective and commented that:

> *Lindiwe:* *I don't really like studying in groups, unless its like after, maybe like two days before a test or exam and we ask each other questions, but generally I can't study in a group. (4;35)*

Sensing / Intuitive

Richard scored a 3 for sensing on the sensing / intuitive dimension indicating that he is fairly well balanced on the two dimensions. In the interview Richard enquired about the definitions of the two dimensions. He then stressed that he hated learning facts and felt that he was more intuitive than sensing.

> *Richard:* *I hate parrot study. (3;54)*

Visual / Verbal

According to the results of the ILS, all of the students interviewed were predominately visual and all of the students, other than Joseph who believed that he was more verbal than the instrument had measured, concurred with this assessment.

Gill *I like spider diagrams, I like seeing all my work on one page so, like if you look at some of my maths notes, I write everything on one page so I can study everything that's there, I don't like going through pages and stuff, so if I have a spider diagram and they ask me a question I'll say oh that was on that corner and then I can see what was there, so spider diagrams and pictures and all that. (5;43)*

James: *Yeah I agree (that he is visual), cause when I was in matric I got the [xxxx] who told me that if you want to understand your work then you must use both parts of your brain and so on, that's why I like seeing pictures, drawing mind-maps and just get it from pictures.(4;21)*

Lindiwe: *I tend to forget words,… I actually learn with pictures. (5;10)*

Sequential / Global

Gill's score on the sequential / global dimension indicated a moderate sequential preference. In her comments Gill showed a need for both the big picture (global) and an understanding of material in logical steps (sequential). This is aligned with Felder and Solomon's (2004b) comments that everybody is one category sometimes and another category at other times.

Interviewer: *It says that you're medium sequential would you agree with that?*
Gill: *It's important to have the big picture, but I think I feel the need to have the little steps first, before you have the big picture. (6;4)*
Interviewer: *Okay*
Gill *So if I don't get the little steps then I don't get the big picture, so rather focus on the little steps first.*
Interviewer: *… some people like to have the big picture first and then the steps.*
Gill: *Yeah, I like, at the beginning of a course, ones I haven't done yet, like they do it in FAC and BCO and Computer Science where they tell you like this is what you're going to do, and I like that. (6;15)*

.

James and Lindiwe each agree that they are fairly sequential and comment as follows:

James: *when I'm studying, I start with a piece which I understand first and then go on go on go on, maybe step only. (4;39)*
Lindiwe *for me to understand the whole, lets say for example to understand a whole concept, I've got to really go thorough it step by step. Otherwise if I try and just understand it and not go step by step I end up not fully understanding it. (5;19)*

Corroboration of Learning Style

It was interesting to observe students making comments elsewhere in the interview that corroborated their learning style preference, for example:

When discussing how Gill goes about learning graph theory compared to inductive proofs, Gill used examples that confirmed both her visual and sequential preferences.

> *Gill* *That's more pictorial, graph theory, so if you can picture that, umm it has to be direct then know that it has to go that way. Whereas induction is more thinking and step-by-step. So graph theory is more pictures, so if you can see the picture then it's fine. And then like vertices, there's 6 vertices, so you just draw 1, 2, 3, 4, 5, 6. And then edges, you have to make that there's 7 edges and draw it, so it's more pictorial (7;37)*

Felder and Solomon (2004b, pg 1) note, "Sensors are more likely than intuitors to resent being tested on material that has not been explicitly covered in class". When discussing an answer to a learning approach question in the questionnaire, Gill emphasised the following, which supports the results of the ILS that she has more of a sensing than intuitive learning style.

> *Gill:* *so if they ask me stuff in the exam that they didn't give me, then I'm very cross because they didn't tell me to learn it. (9;14)*

It is evident that although not all the students agreed with all the results of the ILS, to a large extent the results of the ILS were verified by the interviewed students. In addition, the interviews provided some deeper insights into the students' learning styles. In the next section, the learning approaches adopted by the interviewed students are examined to some level of detail.

7.3.4 Learning approaches

One of the primary aims of conducting the interviews was to try to obtain a deeper understanding of the learning approaches of a few students. Although this was primarily explored through three questions in section five of the interview schedule, insights were obtained throughout the interview.

When examining the results of the interviews, it became evident that there were a number of perspectives from which the data could be viewed. One way was to examine the different responses to the three learning approach questions mentioned above. Alternatively the responses of each student could be analysed. However, it was evident

that more value would be obtained if common themes were identified and the responses discussed under these themes and threads. An obvious theme was the different learning approaches of the students: surface; deep; and strategic. Another approach was by the "groups" of students: excelling; competent; and struggling.

After searching for the "best" way to categorise the data, I realised that there was no right way, and that from each perspective something different was seen and understood. I therefore decided to summarise and categorise the data according to a number of themes. However, based on the research question: "What are the learning approaches used by students studying the FAC course?" I decided to first structure the discussion according to the groups of the students: excelling, competent and struggling and to summarise what learning approaches the students within these groups appeared to use. Within each of these groups of students I looked for comments from the students related to the following characteristics of learning approaches: motivation and intention; process (comprehension and operation learning); and holistic and atomistic.

Other themes that emerged from the analysis, for example language issues and a request for solutions, are discussed in the following section.

7.3.4.1 Précis of learning approaches followed

I compiled a matrix to examine the data. From this it became evident that each student displayed a mixture of learning approaches: surface, deep and strategic. Although somewhat dubious to précis the data as some of the nuances are lost, the predominant approach followed by each students for a number of aspects are summarised in Table 7.8. This made it possible to get an overall impression of the predominant approach followed by each student. Many, but not all, of the details and nuances are given in the discussion following the table.

It also became evident that individual responses could be classified in a number of ways and that the responses to the entire interview as well as how well the student was performing (the outcome) had to be taken into account. For example, Joseph noted that he "crams" for exams. This is characteristic of a surface approach, however as Joseph is an excelling student, this approach could also be viewed as strategic as Joseph is ensuring that he knows all the definitions and aspects that need to be memorised to get very high marks in the exam.

Table 7.8 Predominant learning approach followed by the interviewed students

Group	Student	Motivation	FAC in general	Inductive Proofs	Graph Theory	Algorithms
Excelling	Joseph	Intrinsic in general FAC Not his favourite	Highlights important items Versatile Crams	Highlights important items	Highlights important items	Has learnt from writing programs
	Duncan	Personal intrinsic FAC Not his favourite	Intuitive Holistic	Pure Practice. Quite Easy	layout of solution Intuitive	Develop a template; layout of solution; Memorise;
Competent	Gill	Vocational Relevance; No intrinsic desire	Abstracted out the processes required	Operation learning tending to "improvidence"	Memorisation & a method developed	Forgotten definitions; Understands a process to follow
	Richard	Easy Interesting	Likes to understand and practice. Learn easy items first	"Globe trotting"	Factual studying;	Get used to way things done
Struggling	Kabelo	Vocational: Extrinsic & intrinsic	Looks for most important items to study	Partial comprehension Marks concern Learn items knows first Examples	Draws what text saying; analyses & reasons	Focus on the test
	James	Vocational interest	Asks himself questions	Comprehension learning	Memorisation Examples	
	Maria	To work on computers	Needs to be "in the mood"	Superficial use of terms with limited understanding of the process	Rote learning	Implement & test.
	Lindiwe	A job that will pay well, but unsure of what will actually do - extrinsic	Comprehension learning	Gave a few unimportant facts	Draws analogies to make the material real	Not sure

Key
Shallow
Deep
Strategic
Not categorised

In a similar vein, “memorisation” and “factual study” have been shown in Table 7.8 to be characteristics of a shallow approach, however in graph theory there is a large component of memorisation required and therefore it would be incorrect to label a student as following a shallow approach based on this particular example.

The predominant learning approaches adopted by the students are discussed below under each grouping of students: excelling; competent; and struggling.

7.3.4.2 Excelling students

The Excelling students both commented that they found the work easy and that they knew it from school. They had therefore adopted a **strategic approach** in many instances so as to maximise marks. It was evident that both excelling students were motivated to learn for personal understanding, but neither said that computer science was their favourite course. They both gave examples of an ability to adopt a deep approach where required, a surface approach at times, but overall a strategic approach was used to save time and maximise marks.

Both Duncan and Joseph showed evidence of adopting **surface approaches with strategic intentions.** Duncan exhibited a very surface strategic approach that focused on getting high marks, for example memorising the exact methodology and steps that had been used by the lecturer so that he did not contradict the lecturer at all when answering test or exam questions.

> *Interviewer: Can you give me an idea of what you do when you study FAC and why you study that way?*
>
> *Duncan: “Look at notes we have. Just step-for-step write out the algorithm until I basically memorises one, so then I have like a template which I then apply to every other one, as what I consider an accurate algorithm may not be considered accurate by the lecturer. The one (technique) as he (the lecturer) laid out in the notes” (3;36)*

> *Interviewer: How do you study for a question on graph theory compared to how you study for a question on algorithms?*
>
> *Duncan: Both pretty intuitive. Main thing for studying them is not so much how to solve the problem, what we are studying is pretty easy. More how to layout the solution, so that it does not contravene anything that he (the lecturer) laid out how we should do it. (4;19)*

Joseph noted that he highlighted important words when reading the notes.

> *From interview notes: When studying FAC, Joseph pages through the course notes and highlights important words. He reads the course notes. He occasionally does an example. (1;48)*

Doing examples is required for studying FAC – so only doing examples occasionally and only reading the course notes would indicate a surface approach, however, Joseph was able to adopt this shallow strategic approach of highlighting important words because he knew the work.

Entwistle in Schmeck (1998, pg 26) highlights that academic learning in higher education generally seems to demand both an operation learning process as well as a comprehension learning process – "a versatile style of learning". Joseph demonstrated that he knew to approach a problem from a different angle if he was unable to solve it initially. This indicates a versatile style of learning and is a characteristic of a **deep approach.**

> *From interview notes:* *Normally he (Joseph) can do a problem easily, if he can't he will think about it in the back of his mind all day and then when he gets home he will try and do it again from a different approach. He does not like not being able to solve something and therefore thinks about it until he has a solution (2;20)*

It became evident, on going through the interview transcriptions from the excelling students, that because the excelling students found the work intuitive and easy I had been unable to uncover how they went about their studying in any detail. In the next section greater detail on how the two competent students, especially Gill, studied, is provided.

7.3.4.3 Competent students

With respect to the learning approach followed, there are few similarities between the two competent students. Gill displayed a high level of metacognition and generally an operation learning approach. Gill identified the underlying structure of the material and was able to abstract out the processes to be applied. However, Gill also emphasised many times that she only learnt what she needed to know for tests and exams. This is a characteristic of a **surface strategic approach**.

> *Gill* *So if they say like for our next computer, if they said to me for Computer Science all you have to study is graph theory and algorithms that's all I'm going to study, I'm not going to go study whatever we've just done, the other stuff and if they ask me that I'll be upset because they didn't tell me to study it, so I don't think its fair that they ask me. (9;34)*

It was evident that with her advanced level of metacognition, Gill was able to identify how she needed to study the FAC course in order to maximise her marks, that is Gill adopted a highly strategic approach to her learning.

It was difficult to identify a core thread in Richard's interview. Overall it would appear that Richard knew that he needed to have a deep understanding of the material, but was adopting a predominately passive surface approach, that is, he had a lack of interest in FAC and he put in little effort. At school Richard did not have to work hard and I suspect that he may have been struggling to come to terms with how hard he had to work to understand FAC. Richard may need to realise that "just practice" will not provide a deep understanding and that more insight and being able to make the connections between things may make the difference. Richard also displayed aspects of strategic learning and noted that he ensured that he learnt and revised what was easy or what he knew so that in the exam he got marks for this.

Richard *I'll first study the easy stuff first and then get it over and done with, and then go onto the hard stuff, preferably because I know that if I get stuck on the hard stuff I'm not going to have time to do the easy stuff, which often ends up being a problem, having not completed the difficult stuff but not finished the easy stuff you know. (13;32)*

Interviewer: *And why is that a problem?*

Richard *You lose marks (13;40)*

Motivation and intention

It is important for Gill for the subject matter to have relevance for her, particularly for her future career. This is often a characteristic of a **deep approach** to learning as it motivates the student to adopt a deep approach in order to understand the material.

Gill noted that she liked Computer Science the least of all her courses and that she chose Computer Science because she had to choose between Computer Science and Physics and thought Computer Science would open more doors than Physics. Nonetheless, Gill still found relevance in studying Computer Science.

Interviewer: *Okay, and what do you think you'll use Computer Science for once you've completed your degree?*

Gill *Well because I want to do teaching, … so at least now I can teach Computer Science or teach computers and then add a bit more of what I've learnt. Because I have learnt stuff that's interesting like induction and em, yeah BCO stuff, … I think that's helpful for when you're doing just computers at school. (3;23)*

Gill noted that her favourite courses were Sign Language and Mathematics and she showed a deep interest and personal satisfaction in studying Sign Language and Mathematics because it was directly linked with her vocational choice of teaching the deaf Mathematics. Entwistle (in Schmeck 1988, pg 23) notes that individuals who are concerned with the "relevance to future career" are vocationally intrinsically motivated.

This intrinsic motivation and joy for learning is a characteristic of a deep approach to learning

Gill: *I'm really enjoying Sign Language, but maths I also really enjoy maths. (2;22)*
Interviewer: *What do you like about maths?*
Gill: *I think, someone said to me, the other day, that, if you are doing something that energizes you, then that is what you should be doing, but if you do something that makes you tired then its not what you should be doing, and when I do maths, and I get a problem that I don't know how to do and I do it then its not like I'm ugh I can't believe its over its like oh yeah now I've got more energy to carry on. (2;33)*
Interviewer: *And Sign Language, why are you enjoying sign language?*
Gill: *I think because I know that God told me I have to go into the deaf, and I know that's where I'm going to be in the future, because I want to teach the deaf maths. (2;42)*
Interviewer: *You want to teach the deaf maths?*
Gill: *Yeah, so I'm really enjoying the course, as that's where I want to go in the future. (2;47)*

On the other hand, Gill did not have an intrinsic desire to study widely on the subject and this is often characteristic of a surface approach to studying. This apparent contradiction could indicate that although Gill enjoyed learning certain subjects, she followed a strategic approach to her examinations, focusing on what is required to get a reasonable mark.

Gill: *Oh no, because I don't, in any subject I don't go and look up stuff. I just whatever they give me I study it and that is what I learn, so if they ask, me stuff in the exam that they didn't give me, then I'm very cross because they didn't tell me to learn it. (9;13)*

There were no obvious reasons and motivations for why Richard studied. Richard noted that he liked one course (Economics) because it was easy and another course (Applied Mathematics) because it was interesting. Furthermore it appeared that Richard was trying to convince himself that there was a reason for studying FAC.

Interviewer: *And the FAC course, you say?*
Richard *It has to be done, I can see, it has to be done (3;44)*
Interviewer *Why can you see it has to be done?*
Richard *It's the basics. I can imagine why they would say someone has to do it* (FAC); *I can't see someone going into extreme programming, but not having done that basic course (4;2)*

Process adopted

There was evidence that Gill followed an operation learning approach, had been able to abstract out the processes required and looked at problems in a principled way. This is a suitable **deep learning approach** in the sciences. "Science students have to rely on operation learning much more than arts students". (Entwistle in Schmeck 1988, pg 48).

Interviewer: How would you go about learning for that (induction) *exam question?*

Gill: *Induction? I would do examples, but I'd first know that you have to do three things: it's the base, then the hypothesis, and then the statement. So I know I must do those three things and then I must know that for your base case that you have to have* n *equals 1, or* n *equals a number, and the second one is* n *equals a letter, and then* n *equals the letter plus 1, so I learn it sort of like a picture, and [xxxxxx] that's how I learn for it [laughs]. And then I know that you must have, and then you draw a line, and this side must equal this side and (6;46)*

Interviewer: You find that? yeah

Gill *Yeah, so then I'd know that you start with 1, that's for your base case, and then you must let* n *equal to* k *and then you just substitute* k *in and then* k *equals 1 and then you just have to make it look like the other one, so I just know what you have to do, and then I'll try examples and then they normally work. (7;7)*

In another example there was evidence of some rote learning, which is a necessary step in this situation, as well as a step-by-step focus on elements of the work.

Interviewer: So if you were to go home today after doing FAC how would you study it?

Gill *I think I'd first read my notes, and then I'd probably write down all the important things, like first definitions and all that, and theorems that you have to learn off by heart, all those things, and then I'd make my own notes on how I think you'd do it, like not, not separately without the books, if they say that this is how you draw a binary, if this is how you do a tree thing [laughs], then I'd say okay then you must take, go to the left, then go to the right, so I use my own words instead of using their sub trees and all that stuff, so I use my own words and yeah, I make sure I have all the notes but then I put them in my own form. (6;29)*

Gill *That's more pictorial, graph theory, so if you can picture that, umm it has to be direct then know that it has to go that way. Whereas induction is more thinking and step by step. (7;37)*

Although an operation learning process, (similar to the algorithmic approach referred to by Case and Gunstone (2002)), enabled Gill to master a lot of the material, she did not excel in the FAC course. This could be because Gill fell into the pathology of improvidence, as discussed by Entwistle and Ramsden (1983), and relied too much on a serialist strategy and failed to see how the various elements of FAC interrelated and how FAC fitted into the subject area in general. In addition, from the interview there was little to no evidence that Gill also adopted comprehension learning where relevant. Entwistle in Schmeck (1998, pg 26) highlight that academic learning in higher education generally seems to demand both an operation learning process as well as a comprehension learning process – "a versatile style of learning".

Unlike Gill, although Richard commented that he had to understand the work, there was little evidence that Richard had abstracted out the processes required or that he spent much time studying FAC.

Richard: *Say I was to study complexity, I can't learn, I don't like to learn facts, go read the page and study a proof and then, … I like to understand, I have to practice those, for me to get them right. (7;2)*

Richard *I let it sink in, that I don't go and revise what I did during class, its too much. (7;21)*

Richard: *It has to be practiced, again I can't learn how its laid out, I have to understand. I have to practice examples. (7;33)*

Entwistle (in Schmeck 1988) discusses some pathologies of learning which were discussed in chapter 3. It appears that Richard may display some symptoms of one of these pathologies, namely **'globetrotting'** which is often "associated with an over-readiness to reach conclusions without examining the supportive evidence".

Richard *I check the way I did it, if it seems right, does my answer seem logical. (7;42)*

Interviewer: *How do you ascertain that it seems logical?*

Richard *I look at say the question, and say, I can see what its going to be, in my head, but now its just getting there. I can see the last step, in my mind, I can see therefore this, but its getting there that's the problem for me, so I practice that part, and if my answer is more or less right then I know I'm on the right track, even if its not completely right, if its close to the answer then, its close enough. (8;1)*

This approach that "close enough" is good enough is not appropriate for the FAC course. Rigour is required and getting all the steps right is required. A more structured, detailed approach is required to master FAC. Interestingly the above quote from Richard also displays Richard's global learning preference.

In the next section the approach adopted by the struggling students is discussed along similar lines to that used for the competent students.

7.3.4.4 Struggling students

Reviewing Table 7.8 it appears that two of the struggling students (Kabelo and James) displayed predominately a deep approach to learning, one student (Maria) predominately a surface approach and one student (Lindiwe) a mixture of surface and deep. During the interview only one of the struggling students (Kabelo) gave responses that indicated a strategic approach to learning. However, the mixture of surface and deep approaches adopted by Lindiwe could indicate an overall strategic approach to learning, this will be explored below.

Kabelo was the only struggling student who displayed aspects of a **strategic approach** to studying. He noted that he would focus on the most important aspects when studying for

a test, that he would ensure that he learnt what had been on previous past exam papers and that he would ensure that he learnt what he knew well so that he would get it correct in the exam.

Interviewer: Okay, if you had a test tomorrow okay, on FAC, what would you do today to prepare for that test.
Kabelo Well I will look at the most important aspects, such as inductive proofs, and direct proofs and the contradiction kind of thing (9;13)
Interviewer How do you decide what's important?
Kabelo I have em, you know question papers, so yeah past question papers em, if there's something which is in the question paper I have to make sure that I know it (9;23)

Interviewer: How are you going to prepare for an exam question on inductive proofs?
Kabelo Well although I know inductive proof well, I have to like before the exam I have to like prepare for it yeah, the most yeah actually it's the proof which I know the most so I have to, which I know the most I have to get it. (9;42)

James did not display any characteristics that one would readily classify as a surface approach and the way he responded could be classified as a **deep approach**. James noted that he first studied the material, then asked himself questions, and then he sought equations to practice. This is generally an appropriate deep learning approach for FAC. However, it was not evident if James had been able to abstract out the processes required to master the FAC topics and whether he tried novel questions.

Interviewer: Can you explain to me, how you study and learn the FAC course and why you do it that way?
James I check my notes, then I see which [xxxx] I already [xxx] first time, then I will study it, then I ask myself questions about [xxxx] aspect question from that part, then answer, then if it needs a little bit of practice, then get some equations to practice, then I will just practice. (5;17)
Interviewer: And how do you practice?
James Like say, give me another question which I would like to do, then do it from now on, and then check whether its correct. (5;24)

Interviewer: And when you practice can you explain to me, or give me an example on how you actually practice, what do you do?
James Whew, I just write the question, okay, then close that page, then do it, or I'll try to get there, if I get wrong, then I go back and check where I did wrong. (6;16)

A **surface approach** to learning was a prevalent characteristic of two of the struggling students, Maria and Lindiwe. Kabelo also displayed some aspects of a surface approach in his focus on what will be in the tests and how to get marks, but this could also be viewed as a strategic approach. Maria and particularly Lindiwe replied with a few unimportant terms when answering the interviewer. At a superficial level Maria showed that she was able to use some of the terms correctly, (for example the base case), and to

talk about the very basic process (the inductive step and the need to show that left hand side equals the right hand side). However, there was no depth to her answers.

> *Maria* *Inductive proofs, I first find out how do I find the base case, like what do I have to do to find the base case and then how do I prove them, so I most of the time it's proving the left hand side equals the right hand side and then the inductive step where I'm going to find my inductive, so I'll first find out how I find the base case and the inductive step and experiment to prove that there is two (6;37)*

Lindiwe referred to the sigma notation which is a standard mathematical notation which is used in induction proofs but it is not the essence of inductions.

> *Lindiwe* *I've forgotten how to do the inductions and sigma notation, so because apparently, okay Paul said it was the shorthand method to do mathematical induction, so I will go through that. (6;31)*

Lindiwe also referred to inequalities, and factorials. It appears as if Lindiwe is focussing on specific tutorial examples rather than abstracting out the process. This shows a lack of depth and is characteristic of a shallow approach to learning.

> *Lindiwe* *Okay, I'm going to, I'm going to have to find a text book and read about the, about mathematical induction, and then go through it step by step to see how its actually done, and then from there, hopefully I will understand, and then I've got to go through some examples on inequality yeah, proving inequalities, and the factorial (6;39)*

From a number of Lindiwe's responses it seemed Lindiwe was thinking about how she should study the course, rather than how she had studied the course. For example, she commented that she would probably call a friend. Lindiwe also gave a very superficial description of how she studied FAC and focused on the high level action she should take, for example calling a friend, rather than on the details of how to study FAC.

> *Lindiwe* *and (hesitates) probably call a friend, and ask them if they can do (voice goes softer) [xxxxxxx] then a question, and ask them if they can do it, and then arrive at the same answer as me I know I'm on the right track. (6;12)*

Although Lindiwe made a few comments that indicated limited aspects of a deep approach to learning, for example relating FAC to Mathematics and drawing analogies (examined below), the overall impression from the interview was that Lindiwe was not engaging with the course. Lindiwe was able to mention a few unrelated facts and unimportant details. This is characteristic of the outcome of a passive, surface approach. From the interview responses Lindiwe demonstrated no insight of how to study the material from the FAC course. It was also evident that Lindiwe wanted to learn how to write programs (that is how to write html and java). This is not what Computer Science and FAC are geared for. One of the reviewers of how the interview responses were

classified noted that he agreed with the above summary and that he "would be rather surprised if she (Lindiwe) passed the course based on how she has responded here". This is the only interviewed student that this comment was made on and interestingly this is the only interviewed student who failed the FAC course.

Process adopted

Comprehension learning, a process used in a holistic strategy, is a characteristic of a deep learning approach where there is a global focus and properties can be combined and understood simultaneously. Only the struggling students showed evidence of comprehension learning. However, this does not indicate that the excelling or competent students are not practising comprehension learning, just that they did not highlight it in the interview. Entwistle (in Schmeck 1988) delineates comprehension learning as relating ideas.

Some of the struggling students gave examples of relating concepts within the FAC course and other struggling students gave examples of relating concepts across different courses.

Kabelo: *and we actually use it (inductive proofs) to prove the graph theory. (5;13)*
James: *First I know induction is also on maths, so I will just look for papers and textbook from that course. (6;8)*
Lindiwe: *Usually I refer to my maths text books, because FAC is basically maths. (5;42)*

Although comprehension learning was displayed by the struggling students, the examples above show that the comprehension learning was at a fairly shallow level of relating ideas to other parts of the course and not to prior knowledge. In addition, there was very little evidence of the struggling students having abstracted out the process required to solve problems. That is there was no evidence of an operation learning approach by the struggling students. As commented on above when discussing the operation learning approach adopted by Gill, there is a need, particularly in the sciences, to adopt both an operation learning process as well as a comprehension learning process.

Lindiwe shows another feature of a holistic strategy which is "to rely heavily in their learning on analogies, illustrations, and anecdotes in bringing the academic learning closer to their everyday experience" (Entwistle in Schmeck 1988, pg 26)

Lindiwe: *I really want to grasp what I am studying, I'll [xxx] in graph theory there is binary search trees, and then there's a root and then there are siblings, descendants, so I can like, lets say try, lets say write some names of people*

> *that I know, okay lets say for example, take my family as an example, [xxxxx] this person is the ruler of the family and these are siblings, and this is, okay, this [xxxx] and that is an ancestor. (7;24)*

Although, the use of analogies is considered a sound approach to understand the material, it would appear that Lindiwe, who put binary search trees into a genealogical sense and drew analogies to assist her in understanding the material, was just scratching at the periphery of the work and did not apply this approach to the essence of the material and hence did not obtain a deep level of understanding of the majority of the material covered.

In the next section, other themes that emerged from an analysis of the interviews are discussed.

7.3.5 Other emergent themes

Whilst analysing the interviews a number of interesting themes emerged that are linked to learning styles and approaches. These are discussed below:

- Use of books (section 7.3.5.1)
- Use of lecturer / tutor (section 7.3.5.2)
- Seeking solutions (section 7.3.5.3)
- Metacognition (section 7.3.5.4)
- Terminology and Language (section 7.3.5.5)

7.3.5.1 Use of books

There is no prescribed book for the FAC course. The students are provided with course notes and are encouraged to use library books. Although there was no direct question on the use of books in the interview, a number of students, four out of the eight students interviewed, highlighted that they made use of library books. Interestingly, it was primarily the struggling students who mentioned the use of books, that is three of the four students who mentioned the use of books were students struggling with the FAC course.

Kabelo, a struggling student, referred to the use of books, and in particular library books a number of times. He gave two reasons for getting books from the library: firstly because the notes did not have enough information and later because the lecturer told them to get library books.

Kabelo *Well I take my notes from the lecture and I try to get books from the library and I think the notes are not, they don't have much information so I have to fetch some computer books yeah. (8;29)*

Interviewer *And then what do you do when you get the books?*

Kabelo *I look for relevant sections (8;35)*

Interviewer *Okay, and then? How do you ….*

Kabelo *I like compare the notes with the book (8;39)*

Interviewer *Okay, and what do you do when you go through the books, try and explain to me, tell me what you do, you take the book and what do you do then? You find the relevant section?*

Kabelo *Yeah I read the relevant sections, yeah and I like make sense of what's in the notes and if there are differences.* (9;1)

Aspects of the above quotes, for example comparing the notes with the information in the books and trying to identify differences, indicate a deep approach to learning as Kabelo was focusing on trying to understand the material.

Later Kabelo noted that he took books out of the library because the FAC lecturer kept telling them to do this. This indicates more of a shallow than a deep approach to learning. Kabelo emphasised it was difficult to know what books to take out.

Kabelo *I have to yeah I have to, he always says you have to go to the library and find some books. (14;8)*

Interviewer *And do you find the books help?*

Kabelo *Yeah, but its difficult to get them, you actually don't know which kind of books are important you know. (14;17)*

Two other struggling students, Lindiwe and James, noted that they used mathematics books as FAC has a lot in common with Mathematics.

Lindiwe: *Usually I refer to my maths text books, because FAC is basically maths. (5;42)*

James *First I know induction is also on maths, so I will just look for papers and text book from that course, cause in Comp Sci there are not too many on induction. (6;8)*

James and Lindiwe also noted that they get extra examples and questions from books.

Lindiwe *I will go to a library, try and find books which I hadn't used before, and look at the example and try and do them and the extra questions in the book I would try and do them. (6;9)*

James: *When I'm studying, I'll first study my notes, then try to get some other equations* (examples) *which I can get from Computer Science books. (6;35)*

The fourth student who highlighted the use of library books was Duncan, one of the excelling students. Duncan emphasised that many books were required to cover all the material taught in FAC.

Duncan: *Okay, the first thing I notice about it, is it is very fragmentary,… and you can't find it all in a single book what you need to study. So you get the graph theory and like induction from one book and something else from another book so you end up taking out like five books from the library which is like*

slightly annoying, for about ten pages from each one. So basically its work through all of those (the books). (3;27)

The other excelling student, Joseph, noted that he does not get books out of the library for FAC.

In reply to questions, both of the competent students, Gill and Richard, noted that they did not take books out of the library. Richard elucidated that he could not find anything of value in the library, as it was either too complex or already contained in the notes.

Interviewer *Do you use text books then or not?*
Richard *Out of the library? (10;40)*
Interviewer *Yeah*
Richard *No. Lecture notes and (10;44)*
Interviewer *Your reason for that?*
Richard *I can't find anything of value in the library, its all either extremely complicated or I've already got it in the notes. I have tried to. (11;1)*

Gill further expanded that she considered the use of library books as research and she did not like to do additional research, but to focus on what the lecturer tells the class to learn for exams. This is a characteristic of a shallow strategic approach.

Interviewer *Do you study from library books, or*
Gill *No, that's research, library books are research. (9;43)*
Interviewer *You don't go*
Gill *I just study what they give me*
Interviewer *Okay*
Gill *But if they say in the notes that these aren't all the notes and we will be tested on other stuff then I'll go and look up stuff, if they don't tell me that then I don't. (10;1)*

It is interesting to note that the FAC lecturer encourages the students to take books out of the library, but because no additional material from the books will be examined, Gill does not take books out.

Referring to library books could be considered a characteristic of a deep approach to learning, as the student was sufficiently interested in the subject matter to try and get a deeper understanding of the material, by reading wider than only the course notes. Based on this "guideline", three of the struggling students would be viewed as adopting a deep approach to learning. On analysing the motives for consulting books, one of the students noted that he consulted books because the lecturer told the class to do this, this is a motive associated with a surface or strategic approach to learning. Two of the other struggling students were seeking additional examples to practise; this is a good approach to adopt to master the FAC course.

7.3.5.2 Use of lecturer / tutor

The FAC lecturer noted that he encouraged the students to hand in examples to him for checking and that he had consultation times that students could come and see him for assistance. However, during 2004 no students handed in any material for checking and only a very small number consulted directly with him. Although some of the students interviewed commented on seeking assistance from the lecturer, it was not evident if any of the students interviewed did actually consult the lecturer.

On analysing the interviews it became apparent that only the struggling students commented on going to the tutors or the lecturer for assistance.

Interviewer	*How do you make sense of it?*
Kabelo	*Well I have to first like read the text and then if there are some differences from what they have on the notes I have to like ask the tutors. (9;7)*
Interviewer	*If it doesn't work for you, what do you do then?*
James	*Then I'll go first I'll ask my friend, then if [xxxx] then I'll go to my Lecturer. (6;45)*
Interviewer	*Okay. Have you gone to your Lecturer at all?*
James	*I ask my tutor. (7;3)*
Lindiwe	*Okay, during the tuts I try and ask my tutor to help me with the areas I [xxxxx] and if I still don't understand the notes then [xxxxxxx] I go to Ian* (the FAC lecturer). (6;21)

On three different occasions in the interview Maria commented on asking the tutors for assistance: if she does not understand the work; to seek an explanation if an algorithm is not working; to get solutions.

Maria	*If I don't understand stuff I go and ask my tutor. (6;15)*
Maria	*And see if its* (the algorithm) *going to work, if it* (the algorithm*) doesn't work then I'll see my tutor, ask him to explain why the algorithm is not working. (8;9)*
Maria:	*So we never get the chance to see the solution and see if what we do is right. You have to go and ask your tutor. (9;12)*

During the interview, Gill, a competent student, mentioned that you can ask the lecturer for assistance, but that she felt that they were too busy to assist.

Gill	*And you can ask the Lecturers but its just, I don't know, sometimes you just feel like its wasting their time because they're so busy. (10;43)*

I have not classified seeking assistance from a lecturer or tutor as either a deep or surface learning approach. The student could either be engaging with the material and seeking to understand the material, a characteristic of a deep learning approach, or the student could

be trying to obtain solutions that he/she could memorise, a characteristic of a surface learning approach. What is relevant from a profile perspective is that the struggling students all commented on seeking assistance from the tutor or lecturer, whereas the competent and excelling students did not comment on making use of this option for themselves.

7.3.5.3 Seeking solutions

The FAC lecturer noted that he and the other lecturers of the Computer Science first year courses do not like to provide model answers as they have found that some students tend to memorise the solutions rather than using the model answers to understand the material. The FAC lecturer gave an example from the recent June 2004 examination where two students in answering an exam question gave verbatim a model answer that had been provided in the FAC class, including the lecturer's explanatory side comments. It was evident that these two students had memorised the model answer and were unable to answer the specific question given in the examination.

In order to understand the interviewed students' views on solutions, all the students' responses referring to solutions were analysed. Two of the struggling students, Lindiwe and Maria, specifically commented that they knew the lecturer did not like to provide solutions, but they believed it would assist them.

Interviewer *Okay. Do you think the FAC course can be changed to help you do better?*

Lindiwe *They could, give us more examples because they don't really give us that many examples, give us more examples and also solutions, solutions to the [xxx] and to exercises. They don't give us solutions, but Ian* (the FAC lecturer) *says he doesn't like giving us solutions, because he wants us to go to him if we got problems (8;29)*

Interviewer *What do you think they could do differently? How do you think it could be changed for you to do better? What do you think you could do differently or what do you think the Lecturer could do differently?*

Maria *You know if only maybe the Lecturer, you know we go to a tut, if only the Lecturer will give us, I'm not saying he should do for us, but let us do the tutorials and then give us the solutions. Because what he does now, he do the tut, so we never get the chance to see the solution and see if what we do is right. You have to go and ask your tutor, and then sometimes the tutors are not even there, and then maybe you're writing a test the next day so you don't know what you're doing is right then go do the same thing as you did in the tut and fail the test. So if only they could just give us the solutions to the tuts (9;9)*

Another struggling student, James, noted that he looked for solutions in books.

James *Yeah, I'll be checking books maybe its got solutions. (5;33)*

From the above three examples it is evident that some of the students were seeking example solutions. Although a possible motive may be seeking solutions that they can memorise, I did not get the impression that these particular students were looking to be told what to do and told what is the right answer, but they were looking to see if their answers were correct and if they are tackling the work the correct way. There is little point on practising if you are doing it the wrong way all the time and do not realize this. As discussed above, an option available to the students was to hand in examples to the FAC lecturer for checking, but no student availed themselves of this facility in 2004. It would be interesting to find out why students are not using this available resource.

In reply to a question from the interviewer on how he would study induction proofs, Kabelo responded that he would try examples on his own before looking at solutions if they are available. This is an appropriate approach to adopt when studying FAC and provides some indication of why students are seeking solutions.

Kabelo	*I have to look at other questions yeah questions, and I try to do them on my own, and then if there are solutions, I then look at them. (10;7)*
Interviewer	*So you try and do some?*
Kabelo	*Yeah, before I look at the solution (10;12)*

Contrary to these students, Duncan, an excelling student, focused on the layout of solutions. I have classified this as a shallow strategic approach as the student wants to ensure that he gets high marks independent of whether or not he understands the work.

Duncan	*Main thing for studying them is not so much how to solve the problem, what we are studying is pretty easy. More how to lay out the solution, so that it does not contravene anything that he* (the FAC lecturer*) laid out how we should do it. (4;19)*

7.3.5.4 Metacognition

Although the students' level of metacognition was not explicitly explored in the interviews, a number of the questions necessitated the students having an understanding of how they studied for them to be able to provide answers to the questions. With one exception, very few students displayed any meaningful level of metacognition. It is difficult to find particular examples, as the answers to the entire interview provided a view of whether or not the student was metacognitive. However, the quotes below provide some evidence of this generally low level of metacognition displayed by many of the students.

In a number of cases, the interviewer probed to try and establish how the students studied and learnt certain aspects, but the students were unable to elaborate:

Richard *It has to be practised, again I can't learn how it's laid out, I have to understand. I have to practise examples (7;33)*
Interviewer *So tell me how you go about practicing examples?*
Richard *I get an example from a past paper, and then practise it. (7;38)*
Interviewer *mmm what do you do, how do you?*
Richard *I check the way I did it, if it seems right, does my answer seem logical. (7;42)*

Interviewer *Okay, so how would you prepare for it, what do you do?*
Kabelo *Em, I don't know (10;2)*

James over simplified the reason for why he was failing FAC. This is an indication of a low level of metacognition.

Interviewer: *Why do you think you're not doing as well as you could James?*
James *Sure because I failed the [xxxxx] test. (8;4)*
Interviewer *And why do you think you failed?*
James *The reason because I was studying on my own, I was not using the [xxxx] resources I've had to use. (8;8)*

Maria focused on how she must feel in order to study and what she physically does rather than how she goes about studying the course.

Maria: *I think firstly I make sure that I'm in the mood for studying, because if I'm not in the mood, I'll never understand it, so I sit on my desk and take out a piece of paper and try to like read the notes and jot down what I understood. (6;11)*

Maria and Lindiwe, both found it difficult to explain how they studied the material and focussed on explaining how they would take out books (commented on in section 7.3.5.1 above), or seek help from tutors (commented on in section 7.3.5.2 above) or friends.

Maria *I'll go, I'll ask my friends the ones that are doing Computer Science with me to help me with stuff I don't understand. (6;26)*
Lindiwe: *I would try and do them, and (hesitates) probably call a friend, and ask them if they can do. (6;12)*

Lindiwe also replied that she did not think a different way was required to study graphs compared to algorithms. The FAC lecturer has emphasised to the students the different nature of graph theory and algorithms as described in chapter 2.

Interviewer *Do you think there's a different way of studying graph theory and algorithms then?*
Lindiwe *No. (7;40)*

From the above it is evident that the four struggling students and the one competent student did not display a high level of metacognition.

Both of the excelling students were able to answer the questions put to them by the interviewer, but because they both noted that they found the material intuitive or easy they did not expand on how they went about understanding the material. Duncan focused

on explaining how he learnt the templates and format used by the lecturer. Joseph explained that he highlighted key words in the notes.

Gill, one of the competent students, displayed aspects of metacognition throughout the interview and I would classify her as having a high level of metacognition. Gill understood that she had been only memorising the work and this had enabled her to pass the tests, but she realised that she did not understand the material and felt that she may need to understand the material to pass the exam and the overall course.

Gill *but somehow I'm passing. I think for this term you're able to just study it, like memorize it, and then you can still pass, in a way. Because, you can ask me now anything about algorithms and this stuff [points to file] and I wont know how to answer you, but then if I study for the exam I'll get 75%, that's what I got for my last test, but you can ask me the same test now, and I wont know, so its only once I've studied it, but I think at the beginning of the year, Ian did tell us that for a while we'll be able to just study and memorise it, and afterwards you have to understand it, I'm going to have to start understanding [laughs]. (4;20)*

This is reinforced later in the interview by Gill.

Interviewer *Have you any idea how you're going to go about learning that?*
Gill *An algorithm is a well defined procedure, and something else, you see that was all memorized. I haven't got a clue what I just said, so I can memorise definitions, but I haven't at all studied algorithms maybe that's why I don't know what they are (8;8).*

With her high level of metacognition Gill displayed the ability to abstract out the studying process and this is key to studying the FAC course.

Gill *Yeah, so then I'd know that you start with 1, that's fore your base case, and then you must let* n *equal to* k *and then you just substitute* k *in and then* k *equals 1 and then you just have to make it look like the other one, so I just know what you have to do, and then I'll try examples and then they normally work (7;7)*

Another example of Gill's high level of metacognition is the very perceptive example she gave regarding the importance of a key concept required to understand an area of the work.

Gill *I don't know, I think its just, I have a mental block with algorithms, like even in BCO, they talk about flip flop. I said isn't that what you go to the beach with? I don't know what a flip flop is. And then she'll explain something and I'll understand it, but as soon as she brings in the word flip flop I'm totally lost, so I think its just one concept that I don't understand, and when I understand that concept then everything else will fall into place, which is the same as it is in algorithms, as soon as I understand exactly what an algorithm is or what I need to know about algorithms then all the rest will fall into place. (14,35)*

In analysing the interview with Gill, it was also evident that Gill understood that different techniques and approaches are required to learn the various components of the FAC

course. The techniques and approaches described by Gill for inductive proofs, graph theory and algorithms are expanded upon below.

Inductive proofs:

The FAC lecturer highlighted that trying many different examples and abstracting out the common steps to follow is an appropriate way of learning inductive proofs. This was the approach followed by Gill.

Interviewer	*How would you go about learning for that (inductive proof) exam question?*
Gill	*Induction? I would do examples, but I'd first know that you have to do three things: it's the base, then the hypothesis, and then the statement. (6;46)*

Graph Theory:

Gill commented that she did not know how to learn graph theory, but her replies indicated that she understood that Graph theory required a level of memorisation and that graph theory examples are different to inductive proof examples.

Gill	*Graph theory, emm Graph theory is more theorems that you have to know, and more concepts so if you know that [xxxx] (7;19)*
Interviewer	*You're doing fine, there's no right answer to what you tell me okay*
Gill	*I don't know how to explain this. emm graph theory? Like if you know that, for this to be true you have to have certain things happen, then you just learn what those certain things are and then when they ask you a question you have to look for those few things, so I don't know how, I don't know how to say it.*
Interviewer	*Okay, let's say you, lets give me an example if you were to go and start learning graph theory, what would you do?*
Gill	*I don't know, I'll would just, I don't know, I don't know how I learn for it.*
Interviewer	*You're doing fine, you're saying its more… Compare graph theory to inductive proofs if you have not learnt algorithms.*
Gill	*That's more pictorial, graph theory, so if you can picture that, umm it has to be direct then know that it has to go that way. Whereas induction is more thinking and step by step. So graph theory is more picture, so if you can see the picture then it's fine. And then like vertices, there's 6 vertices, so you just draw 1, 2, 3, 4, 5, 6. And then edges, you have to make that there's 7 edges and draw it, so its more pictorial. (7;37)*

Algorithms:

Although Gill highlighted in the interview that she had not yet learnt or understood algorithms, she was able to explain that she would learn a process that would enable her to answer the exam questions.

Gill	*Well I know that you have to do these things, I think there's 5 or 6, you have to like describe it and then do a specification and then develop the algorithm and then code it, so I know you must do those things, and its basically all the same stuff, you just have to swap numbers and that. (8;21)*

7.3.5.5 Terminology and language

Two students, one competent and one struggling, mentioned that the language and terminology used in the FAC course were new and difficult.

Gill *I think, its just very new to me, like school was not new, it wasn't. It was stuff you've heard before it was mountains that you've heard the word before, or maths. It was new stuff but it was simple. Whereas now its like all these big words …. Algorithms, and specification and verification, I don't even know what they mean, and then you have to start applying all these things to it, and then if you don't understand the first then you don't understand the rest of it. (11;16)*

Interviewer *Why do you think you're not doing as well as you think you can?*
Kabelo *I think it's the English, the test actually it's like, em its like the Lecturer is teaching, it's like I don't, .. I find myself not understanding what's the question is all about. Its like the English is like first language or something. (13;19)*
Interviewer *You don't understand the question?*
Kabelo *Yeah*
Interviewer *Okay, I haven't got an example, so can we get an example of the sort of question you wouldn't understand?*
Kabelo *There's a question, it was about direct proofs, you actually didn't have to like prove the thing but you have to like explain. (13;30)*

The test question that Kabelo was referring to is provided below.

> Suppose that you are asked to prove the theorem below:
>
> If n is an integer then $n^2 + 2$ is not divisible by 4.
>
> One of your classmates suggests that you can prove the theorem by showing that the result holds for a long list of integers, for example if $n = 2$, then $n^2 + 2 = 6$ which is not divisible by 4, if $n = 7$, then $n^2 + 2 = 51$ which is not divisible by 4, etc.
>
> Is this a valid proof technique to use for proving the theorem? Explain your answer.

I got the impression that Kabelo battled with the question due to having to explain the reason in English. As discussed in chapter 3, this does bring into question the suggestion by Case et al. (2001) to include questions like "Explain why …" to assess the students conceptual understanding as instead of assessing conceptual understanding, agility with the English language may be assessed instead. Given the large number of students studying the FAC course whose first language is not English, it may be worth the lecturer examining the use of terminology and the type of exam questions set that may be testing more the level of English competence than an understanding of the FAC principles.

In the next section, the last aspect explored with the students in the interviews is discussed.

7.3.6 Why students believe they are not performing as well as they could and advice for "improving" FAC

The last question on the questionnaire administered to the FAC class asked the students: "How well do you think you're doing in FAC? Please rate yourself objectively, based on the marks you have been obtaining". In the interview the answers that the interviewed students had given to this question in the questionnaire were explored in greater detail. Specifically, if the student did not feel they were doing as well as they could or doing about average, two questions were asked:

- What do you think you could do to do better, to improve your marks?
- What do you think could be done differently in FAC, or by the FAC lecturer for your marks to improve?

In this section the responses from the students will be analysed under three headings:

- Students view on how they were performing.
- What students believe they could do themselves to improve their marks in FAC.
- What students suggested the lecturer or department could do to improve the students' marks in FAC.

7.3.6.1 Students view on how they were performing

The students' view on how they were performing and their comments regarding this performance are summarised in Table 7.9.

Gill, Richard, Kabelo, James and Maria commented that they believed that they could do better, and that the marks they were obtaining were not a good reflection of their ability.

In reply to section C, of part D of the questionnaire both Kabelo and James commented that they believed that they could do better than they were:

> *Kabelo: "I know I can be much better than this."*
> *James: "I know I'm capable of doing very well and I know I can do it."*

Table 7.9 Views of interviewed students on how they were performing

	Student	**Students view on how they were doing**	**Comment**
Excelling	Joseph	Very well	
	Duncan	Quite well	*Question not explored in the pilot interview*
Competent	Gill	About average	Believes she is capable of doing better. Noted that FAC is not her favourite subject and "battle to grasp all the ideas and stuff."
	Richard	About average	Believes he is capable of doing better – see quotes below, Noted that the time is limited and some of the course material is confusing.
Struggling	Kabelo	About average	Believes he is capable of doing better. Commented that the English is difficult and that he does not understand the questions
	James	Not so well	Believes he is capable of doing better. Commented that he failed because he was studying on his own.
	Maria	Not so well	Believes marks not a true reflection of her ability - see quotes below
	Lindiwe	Not so well	Ran out of time in the tests as slow.

In the interview Maria added that it was stressful, because if a student did not pass FAC they have to repeat the course the following year.

Interviewer: Now, you said you're not doing as well as you think you could, why do you think you're not doing as well as you as think you could?
Maria Because the marks that I've been getting, are not that good, for …. They are not as good as I am. (8;32)
Interviewer As you are.
Maria The marks that I'm getting, so, It becomes stressful to me because in Computer Science in June if you do not pass FAC, you don't continue, you have to repeat next year. So that is why I think I'm not doing well. (8;37)
Interviewer Why do you think you're not doing well?
Maria I failed, like, I failed a test terribly, 35% for a test is so …that is why I think I am not doing well. I'm trying to work on it right now. (8;42)

This focus on failure is a characteristic of a surface learning approach.

In addition Maria's comments that the tests and examinations are stressful bring to mind the recommendations of Case et al. (2001) to provide a "crib sheet", one A4 page only, to help reduce this stress. Lindiwe's comment that she ran out of time in the test is aligned with the findings of Case et al. (2001) that students ascribe their lack of success in a course to test time pressures.

Richard elaborated on why he believed he could do better than the marks he was obtaining were indicating.

Interviewer *Can you give me your view on how you think you can do better in the course?*

Richard *Obviously study more. … I got through school pretty easy, I studied maximum two and a half hours for each matric exam except chemistry and I got a pretty good average, so I'm not used to having to study that hard yet, I'm still getting into things, I know I'll do better in the second half of the year, its bound to happen, so that's why I said I know I can do better, … I know I can do better, so I don't want to put that I think I am doing very well. (11;13)*

Interviewer *So you don't think you're doing as well as you could*

Richard *No, definitely. (11;26)*

Interviewer *And do you think what you can do to change that?*

Richard *Its frightening the marks I'm getting. Its scaring me. (11;30)*

It appears that Richard was not challenged at school and was able to understand the concepts quickly and easily at school, but he was finding that he had to work hard at university.

7.3.6.2 What students believe they could do to improve their marks in FAC.

In the interview the students were asked what they believed they could do themselves to improve their marks in the FAC course. Their responses are summarised in Table 7.10.

Table 7.10 What interviewed students believed they could do to improve their marks in the FAC course

	Student	**Response**
Excelling	Joseph	Not relevant – Excelling in the course.
	Duncan	*Question not asked in the pilot interview.*
Competent	Gill	Put more energy and work into the FAC course.
	Richard	Study harder and devote more time to the FAC course.
Struggling	Kabelo	*Question not explicitly asked in the interview.*
	James	Not study on my own.
	Maria	In reply to the question Maria only noted what the lecturer could do to improve the results and not herself and this was not probed further.
	Lindiwe	Write faster.

Both of the competent students commented that they would need to work harder and put more energy or time into the FAC course.

Interviewer: *Anything you think you could do differently to do better in FAC, to perform at the level you think you can?*

Gill *Yeah I could, I think if I put more energy into it. I think you only put as much energy if you enjoy it, if you don't enjoy it you're not going to bother, so I think if I had to work at it, I would do better. (10;50)*

Interviewer *Okay, and so what are you going to do differently?*
Richard *Study harder, just practise more, devote more time to the subject. (11;34)*

Unfortunately the interviewer did not probe sufficiently in the interviews with the struggling students to find out what the individual struggling students thought they could do to improve their marks in the FAC course. James highlighted that he could do better if he did not study on his own. Lindiwe commented that she believed she was failing because she was slow and that she would need to write faster to do better in tests.

Lindiwe: *I knew the stuff but then its just that I spent so much time trying to answer, trying not to [xxxx] that I actually ran out of time and, I guess that I'm a bit slow, so I run out of time. (8;12)*
Interviewer *What do you think you can do differently to do better?*
Lindiwe *I'm going to have to write faster. (8;19)*
Interviewer *Okay.*
Lindiwe *Because during the last test, when we spent time out and the third question [xxxx] I was like [sigh] I could easily have done this, so I just need to work faster (8;23)*

7.3.6.3 What the lecturer or department could do to improve the students' marks in the FAC course.

All of the students commented on what they believed the department or lecturer could do to improve the students' marks in the FAC course. The suggestions are summarised in Table 7.11.

Table 7.11 What interviewed students suggested the lecturer or department could do to improve the students' marks in FAC

	Student	**Suggestion**
Excelling	Joseph	Bridging course for people who have not used computers before. Use a different programming language that enables more sophisticated programming.
	Duncan	*Question not asked in the pilot interview.*
Competent	Gill	Additional tutorials. Demonstrate the concepts on the computer.
	Richard	Lecturer to be less vague and more clear
Struggling	Kabelo	Simplify the language used.
	James	Additional tutorials
	Maria	Solutions
	Lindiwe	More examples and solutions

When replying to the interviewer via email regarding the verification of the notes taken during the interview, Joseph, one of the excelling students, made two suggestions.

Joseph: *I think there should be a bridging course for people who have not used computers before. The work can then be taught at a much faster pace for those who feel comfortable with the work. (2;38)*

This first suggestion from Joseph raises an important debate: Is a bridging course required for students who have not used computers before? This is aligned with the recommendations of Denning et al (1989) and Yahya (1992), discussed in chapter 2 for a remedial, introductory course for students who don't have an appropriate computer background. The results of the questionnaire discussed in chapter 4 also indicated that students who have prior computer exposure are more likely to do better in the FAC course than those who do not have prior computer exposure. Joseph's suggestion also raises a question: is the FAC course meeting the needs of the excelling students? This last aspect is not explored in this research report.

The second suggestion made by Joseph relates to the choice of programming language used in the course.

Joseph: *I believe using Scheme as a programming language hampers the potential of the programming language. If we were taught using C, java, delphi or a similar language, by being able to perform more sophisticated tasks (including graphics) it should encourage students to experiment more with the language itself, and thereby with the implementation of algorithms. (2;44)*

This topic is not directly within the scope of the research questions and other research is being done in this area at the School of Computer Science at Wits. What is relevant is the inference that students should be encouraged to experiment with the implementation of algorithms. In a discussion with Gill, one of the competent students, she suggested that the concepts needed to be demonstrated on the computer so that the students could see what the different algorithms did. As noted in chapter 2 there are mixed results on the benefits of simulations and animations and this possibility would need to be investigated for the FAC course at Wits.

Two students, Gill and James, suggested that additional tutorials would provide the students with more time to ask questions. Gill also highlighted how easy it was to fall behind with the work.

Interviewer: *How do you think they could do the course differently for you to do better on it? Any ideas?*

Gill: *I think the lectures are fine, like the way they teach the lectures. I think maybe the tutorials, like we have good tutors, but we don't, there's not enough, like we get one tutorial a week and then during that day we do the tutorial then next week we do another one, so we don't really have time to ask like, I really don't understand the whole section of this tutorial so how are we supposed to… so you just get like there's just this whole lot of work*

that you need to try and do and you haven't done it, so I'm now two tutorials behind because I couldn't do the one then the next week I've got a new one so I try to do that and I couldn't do that one and the next week I've got new one so for three tutorials I haven't been able to do them. And you can ask the Lecturers but its just, I don't know, sometimes you go feel like its wasting their time because they're so busy. (10;35)

Interviewer; Do you think there's anything that the FAC course could do to make it easier for you, or to make it, for you to do better?
James: I think there is. (8;15)
Interviewer: And what do you think that is?
James: Maybe if we can organise more tuts on computer, not one per week, and maybe to just add time for us to ask questions on an issue [xxxx] for FAC. (8;19)

This request for additional tutorials and more time to ask questions could indicate a need for some scaffolding of the work. The request by two of the struggling students, Maria and Lindiwe, for solutions could also indicate a need for some scaffolding.

Interviewer: What do you think they could do differently? How do you think it could be changed for you to do better? What do you think you could do differently or what do you think the Lecturer could do differently?
Maria: You know if only maybe the Lecturer, you know we go to a tut, if only the Lecturer will give us, I'm not saying he should do for us, but let us do the tutorials and then give us the solutions. Because what he does now, he do the tut, so we never get the chance to see the solution and see if what we do is right. You have to go and ask your tutor, and then sometimes the tutors are not even there, and then maybe you're writing a test the next day so you don't know what you're doing is right then go do the same thing as you did in the tut and fail the test. So if only they could just give us the solutions to the tuts (9;9).
Interviewer: Okay. You think that would help?
Maria: Yeah I think. Maybe let's say we do the tuts on Thursday, maybe they put the solutions next week, lets say next week Thursday, on the notice board. And so we can go find out what our mistakes, go find out what we did wrong and try. (9;19)

Interviewer: Okay. Do you think the FAC course can be changed to help you do better?
Lindiwe: They could, give us more examples because they don't really give us that many examples, give us more examples and also solutions, solutions to the [xxx] and to exercises. They don't give us solutions, but Ian (the FAC lecturer) *says he doesn't like giving us solutions, because he wants us to go to him if we got problems (8;29)*

The theme of seeking solutions was discussed above in section 7.3.5.3. Another theme discussed above in section 7.3.5.5 is Language and Terminology. In response to the question on how the FAC course could be changed to assist the students in getting better marks, Kabelo suggested that the English be simplified.

Interviewer: How do you think the course would be made so that you could get the marks that you think you could, what do you think needs to change
Kabelo: I think the language the English, that we can try to simplify, to be easy, to be (xxx) (14;28)

Richard's suggestion that the lecturer be more clear and less vague is related to this theme of language and terminology. In section 7.3.5.5 above, Gill's comments on the use of new and difficult words is also related to this theme. Yahya (1992, pg 125) noted that "major consideration must be given to gear the program to take into account the language skills of the potential audience".

To recap, the predominant suggestions from the students interviewed, on ways to change the FAC course so as to assist them in improving their marks, were to provide additional assistance in the form of additional tutorials and solutions and to simplify the terms and English used in the teaching of the course. The FAC lecturer has noted that in the past additional tutorials were run, but attendance at them was very poor. This does not imply that additional tutorials should not be given, but that if it were decided that additional tutorials could assist the struggling students, the reasons for poor attendance would need to be investigated and then taken into account.

A number of themes have been explored in this chapter. In the last section the findings from the interviews are summarised with a focus on the profiles of the students according to the three groups: excelling, competent and struggling. Prior to the summary in the last section (7.5), in the next section (7.4) the results from the questionnaire are compared to the findings from the interviews.

7.4 Comparison with Results from Questionnaire

The questionnaire had four parts: Part A – Demographics; Part B – Computer background; Part C – Index of learning styles; Part D – Study approaches. The information provided by the students to Part A and Part B was confirmed with the students and no inconsistencies were found. In section 7.3.3 above the small differences, between the learning style preferences computed by the ILS for the interviewed students and each student's own view on his / her learning style preference, were discussed. In this section the scores computed from the learning approach instrument are compared with the findings from the interview. This is summarised in Table 7.12 and expanded upon below.

Table 7.12 Comparison of learning approach questionnaire and interview results

Group	**Student**	**Learning approach rating computed from questionnaire**	**Learning approach adopted as determined from interviews**
Excelling	Joseph	4.93	Predominately Strategic Deep where required, surface at times
	Duncan	4.68	Predominately Strategic Deep where required, surface at times
Competent	Gill	2.82	Advanced level of meta-cognition and generally an operation learning approach. Emphasised that she only learnt what she needed to know for tests and exams which is characteristic of a surface strategic approach. Overall a highly strategic approach to her learning.
	Richard	4.93	Predominately passive surface approach, but knew that he needed to have a deep understanding of the material. Some strategic aspects.
Struggling	Kabelo	5.59	Predominately a deep approach to learning with some strategic aspects
	James	4.45	Predominately a deep approach to learning
	Maria	3.68	Predominately a surface approach
	Lindiwe	4.57	A mixture of surface and deep

For the sample population, the maximum learning approach rating computed for a student, using the learning approach questionnaire discussed in chapter 6, was 5.68, the minimum 2.72 and the mean 4.48. From Table 7.12 it is evident that the learning approach ratings computed for the two excelling students from the questionnaire are in agreement with the findings from the interviews.

The learning approach rating computed for Gill from the questionnaire is much lower than I would have expected given the findings from the interview. In the questionnaire sample population Gill obtained the second lowest learning approach rating. On further analysis of the questionnaire and interview it is apparent that even though Gill has a high level of metacognition, she focuses on learning only what is required for the tests and exams. In addition, the operation approach to learning adopted by Gill has more of a surface strategic bias than a deep bias. This returns to the apparent contradiction mentioned in chapter 3 where Case and Gunstone (2002) view an algorithmic approach (very similar to an operation approach) as a form of a surface approach to learning

whereas Entwistle (in Schmeck 1988) view an operation approach to learning as a form of a deep approach. In this particular example it appears as if an operation / algorithmic approach to learning has aspects of a deep approach to learning as the student is able to abstract out a process to follow. However, the student may not understand the process and merely follows the steps in a mechanical manner more aligned with a shallow approach to learning.

The learning approach rating computed for Richard from the questionnaire is slightly higher than I would have expected given the findings from the interview. However, this is probably because Richard knew that he needed to adopt a deeper approach than he was, and therefore for some questions he answered what he should be doing rather than what he actually was doing.

In the questionnaire sample population Kabelo obtained the fourth highest learning approach rating. This is largely in agreement with the findings of the interview although the strategic approach adopted by Kabelo could not be identified from the questionnaire.

The learning approach ratings for the three other struggling students are largely aligned with the findings of the interviews. However, I would have expected a slightly higher learning approach rating for James and slightly lower for Lindiwe.

To sum up, the results of the learning approach questionnaire provided an indication of the learning approaches adopted by the students, but there was not a total alignment between the questionnaire results and the interview results. In addition, the nuances and details of the learning approach adopted by the students can only be uncovered through a qualitative instrument such as semi-structured interviews.

7.5 Summary and Discussion

The excelling and competent students interviewed are all white and their home language is English. All of the struggling students are black and their home language is not English. The intention had been to have a mixture of white and black students in the struggling group. Unfortunately when the students were reclassified based on their class mark, the make-up of the groups changed. The implication is that there are a number of factors that are common for the struggling group and that, as with any qualitative study

with a small sample, caution must be taken neither to jump to conclusions nor to make generalisations based on the findings.

Ironically only the four students who are struggling with FAC replied that Computer Science was their favourite course. However, the struggling students seemed to find it difficult to provide their reasons for this and sometimes provided circular responses. Conversely, the excelling students and competent students were able to provide some deeper reasons for why courses were their favourites.

It is evident that many students are not studying what they thought they would be. These responses support the views of Sanders and Mueller (2000) that some students register for Computer Science to learn about computers and programming and many students are not aware of what they will study in Computer Science. Programming is a common item raised by a number of students, from excelling students to struggling students. Although a number of students are discovering that they are not studying what they thought they would in Computer Science, the objectives of Sanders and Muller (2000) namely that "we felt that our curriculum should be structured in such a way that these mistaken perceptions were highlighted as early as possible in the students' career" are being met.

Students generally agreed with the assessment from the ILS. All the interviewed students had a visual learning style, although Joseph believed he was more verbal than visual. It is interesting to note that the highly excelling student, Joseph, has a fairly unique learning style profile: highly reflective, highly intuitive and highly global, low visual or possibly verbal.

The excelling students both commented that they found the work easy and that they knew it from school. They had therefore adopted a **strategic approach** in many instances so as to maximise marks. It was evident that both excelling students were motivated to learn for personal understanding. However neither excelling student said that computer science was their favourite course, and they may therefore have reserved a deep learning approach for their favourite subjects. They both gave examples of an ability to adopt a deep approach where required, a surface approach at times, but overall a strategic approach was used to save time and maximise marks.

With respect to the learning approach followed, there are few similarities between the two competent students. Gill displayed a high level of metacognition and generally an operation learning approach although also a surface strategic approach at times when appropriate. It was difficult to identify a core thread in Richard's interview. Overall it would appear that Richard knew that he needed to have a deep understanding of the material, but was adopting a predominately passive surface approach with some strategic aspects.

Two of the struggling students (Kabelo and James) displayed predominately a deep approach to learning, one student (Maria) predominately a surface approach and one student (Lindiwe) a mixture of surface and deep. During the interview only one of the struggling students (Kabelo) gave responses that indicated a strategic approach to learning.

Four out of the eight students interviewed, highlighted that they made use of **library books.** Interestingly, it was primarily the struggling students who mentioned the use of books, that is three of the four students who mentioned the use of books were students struggling with the FAC course. On analysing the motives for consulting books, one of the students noted that he consulted books because the lecturer told the class to do this, this is a motive associated with a surface approach to learning. Two of the other struggling students were seeking additional examples to practise; this is a good approach to adopt to master the FAC course.

What is relevant from a profile perspective is that the struggling students all commented on **seeking assistance from the tutor or lecturer**, whereas the competent and excelling students did not comment on making use of this option for themselves.

Some of the struggling students are seeking example **solutions.** Although a possible motive may be seeking solutions that they can memorise, I did not get the impression that these particular students were looking to be told what to do and told what is the right answer, but they were looking to see if their answers were correct and if they are tackling the work the correct way. It could be viewed that they were seeking ways to gain epistemplogical access to the FAC course (Morrow 1994; Rollnick 2005).

With one exception, very few students displayed any meaningful level of metacognition. Gill, one of the competent students, displayed aspects of metacognition throughout the interview.

Two students, one competent and one struggling, mentioned that the language and terminology used in the FAC course were new and difficult.

In order to improve their marks in the FAC course, both of the competent students commented that they would need to work harder and put more energy or time into the course. Unfortunately the interviewer did not probe sufficiently in the interviews with the struggling students to find out what the individual struggling students thought they could do to improve their marks in the FAC course. Two answers by the struggling students were very superficial; one was to study in a group and the other to write faster.

The predominant suggestions, from the students interviewed, on ways to change the FAC course so as to assist the students in improving their marks, were to provide additional assistance in the form of additional tutorials and solutions and to simplify the terms and English used in the teaching of the course. Again this could be a “cry” from the students to “learn how to play the game” - to learn the language of the FAC course (Rollnick 2005).

In summary, the struggling students were looking for additional assistance in the form of using books, seeking assistance from tutors, requesting solutions to problems and requesting additional tutorials. It is also evident that across all groups of students a number of the students interviewed appeared to follow aspects of a deep approach to learning. However, it is evident that following a deep approach to learning does not equate to achieving good grades.

Although students may display behaviour that could be considered attributes of a deep approach to learning, (for example the holistic approach used by Richard, the use of analogies by Lindiwe and the comprehension learning process used by a number of the struggling students), this does not automatically imply that the student was adopting a deep learning approach nor that the students had acquired a deep level of understanding of the material. It is evident that one cannot simply equate some evidence of a student following a holistic strategy or a comprehension learning process, both attributes of a

deep approach to learning, to a comprehensive level of understanding of the subject. There could be a number of reasons for this, not least of all that student's responses must not be viewed in a piece-meal manner.

A further possible explanation is provided by Entwistle (in Schmeck 1988) who notes that deadlines can interfere with students' intentions. This was discussed in chapter 3. For example, a student may plan to obtain a deep understanding of the material. However, if the student first adopts a holist strategy, but then runs short of time to understand the details of the material he / she will not be able to answer the exam questions.

It is evident that the excelling and competent students displayed a strategic approach to their learning. However, apart from Kabelo, there was very little evidence that the struggling students adopted a strategic approach to their learning.

Drawing on the literature reviewed and the findings from the interviews I did some surmising. I put forward that many of the struggling students had the intention to adopt a deep approach to their learning as this is the approach that is actively encouraged by the FAC lecturer. A simple example is their use of library books. However, for various reasons, including a heavy workload and inadequate prior knowledge, they were not able to complete the process required to obtain a deep understanding of the material. In addition, these students may not have had training in a strategic approach to learning and therefore did not pay sufficient attention on how to maximise their marks in the test and exams. The end result was poor grades. The students had not learnt how to "play the game" (Rollnick 2005).

In the last chapter, the findings from the interviews as well as the questionnaire will be consolidated and discussed.

8. DISCUSSION OF FINDINGS AND RECOMMENDATIONS

8.1 Introduction

The focus of this chapter is to bring together and discuss the results presented in the previous chapters and to answer the research questions. First, to provide a framework for the results, the research rationale, aims and methodology are summarised. Secondly, to provide a context to the study, an overview of the FAC course and the 2004 FAC class is provided. The results of the study are then discussed in some detail. Attention is then turned to answering the three research questions. Some recommendations based on the findings are suggested and then finally some of the limitations of the study and some possible future research directions are put forward.

8.2 Research Rationale, Aims and Methodology

There is a very high failure rate in the FAC course which is one of the modules of the first year Computer Science course at Wits. Consequently, the FAC lecturer wished to investigate some of the factors contributing to this, especially those factors over which he had possible influence, in particular students' learning styles and learning approaches. Therefore, three questions were posed to be answered by the research:

1. What are the various learning styles of students studying the FAC course?
2. What are the learning approaches used by students studying the FAC course?
3. What, if any, relationship is there between learning approaches, learning styles and student success?

The research study was primarily exploratory in nature as a result of the research questions to be answered. Two research designs were selected: a survey to get a broad overview of a large sample and an ethnographic design to provide an in-depth description of a small group. There were thus two samples: 99 students from the FAC 2004 class participated in the survey; eight of these students were selected through purposive sampling to be interviewed.

The results of the survey were analysed using descriptive statistics including correlation analysis as well as t-tests to determine the level of significance of the results. The responses to the interviews were categorised, analysed and synthesized. The findings of the study are integrated and discussed in section 8.4 below, but first some background to the FAC course and the FAC 2004 class is provided.

8.3 Background

It is important to have a background and context in which to understand the results of the study. Therefore, the FAC course is first described and then a picture of the 2004 FAC class is provided.

The FAC course is one of five modules taught in the first year computer science course at Wits. The FAC course is a difficult conceptual course that covers proof techniques and introduces algorithms and data structures. Algorithms are part of the theory of computing, but most students struggle learning it, not only at Wits, but also at many other Universities. For example, Grinder et al (2002) note that it can be tempting to forego teaching the theory of computing as most students struggle with it and seem to retain very little of what they are taught. However, the theory courses, such as FAC, put the "science" into computer science and it is imperative that FAC is not only taught, but also understood by the students.

In 2004, 166 students were initially registered for the FAC course, of these 161 students wrote the final FAC exam in June 2004. The class comprises a majority of young, black males. There are only 21 females in the class. The average age of the class is 20 years. 64% of the class are black, 22% are white, 12% are Indian and 2% are coloured.

In order to be accepted into Computer Science, the students have to have achieved good mathematics marks (a C which equates to above 60%) on the higher grade in their final year of school (their matric year). On average the students in the FAC class obtained over 68% for matric mathematics. However, even with these solid mathematics marks, a large percentage of the class (50%) failed the FAC course in 2004. The average class mark for the FAC course was 52%.

The focus of the study was on the learning styles and learning approaches of the FAC students and what, if any, relationship there is between learning approaches, learning

styles and student success. Before these findings are summarised, it is first important to understand if there were other variables that were possibly related to the FAC course mark as these could have a bearing on the results of the study. An exhaustive study was not carried out, but some pertinent relationships were revealed.

Interestingly, although only 14% of the sample was female, no correlation was found between gender and FAC course mark. However, as to be expected, there is a positive correlation between matric mathematics marks and FAC course mark (r = 0.36), as well as between prior computer exposure and FAC course mark (r = 0.38).

There is a statistically significant difference between the average FAC course mark for black students (46.6%) and the average FAC course mark for non-black students (63.2%), (p=0.00). Based on the sample data only 38% of the black students passed the FAC course whereas 91% of the non-black students passed the FAC course. There could be multiple reasons for this difference in pass rate, for example, the non-black students obtained higher matric mathematics marks (77.8% on average) than the black students (65.9% on average). The results of the questionnaire also indicated that in the FAC class, non-black students have greater prior computer exposure than black students. However, there are many other factors that were not investigated that could also be linked to black students and course mark, therefore no causation can be attributed to these factors

In the next section the results from the research into the learning styles and learning approaches of the FAC 2004 class are discussed.

8.4 Discussion of Results

The study was undertaken to try and get some understanding as to why there is a high failure rate in the FAC course. The two constructs that were examined as possible indicators of success in the course were the types of instruction to which students respond best (learning styles) and the way students approach their studies (learning approaches). Any discussion on these two constructs must be viewed alongside the limitations of the two constructs as discussed in chapter 3, that is that learning styles are relatively invariant and characteristic preferences of the learner whilst learning approaches tend to vary from task to task. In addition, some researchers question their meaning and even their existence. The limitations of the instruments, as discussed in chapter 4, used to determine the

learning approach and learning styles of the students must also be borne in mind, in particular that the instruments were not specifically designed for the computer science discipline.

Regarding learning approaches, it was found that there was very little direct relationship between students' grades and the use of shallow or deep learning approaches. Contrary to the lecturer's anecdotal view, students who failed the course were not necessarily adopting a surface approach to their learning. Similarly, the adoption of a deep learning approach, which was encouraged by the lecturer, did not imply good grades. In addition, contrary to Haggis' (2003) views that a deep learning approach is "elitist", many of the black students, who would probably not be considered "elitist", adopted a deep learning approach. Some insights into these unexpected results were obtained from the interviews as well as the profiles drawn which associated the use of certain learning approaches with high and low grades in the course.

There was a group of students who obtained low marks and yet were adopting a deep approach to their learning. That is, students using deep approaches were not necessarily successful in the course. The profile obtained showed that those students who expressed views displaying a deep approach to learning, but who obtained low course marks, showed a **non-strategic** approach to their studying. That is, these students did not think they should focus on learning the information they needed to know to pass, as learning was about broadening the mind and not just passing.

James and Kabelo did not fall directly within the profile of deep learning approach and low marks as they both passed the course. However, although both passed the course, both were viewed as struggling students as James only achieved 52% for the FAC course and Kabelo 55%. In both the questionnaire and the interview James and Kabelo showed characteristics of a deep approach to learning, and one therefore asks why did they not achieve higher course marks? Some possible reasons within the theoretical frameworks of learning approaches and learning styles are explored below. However the relationship is clearly more complex than simply examining these constructs and there are many other possible reasons for students not getting good grades, ranging from factors such as ill health to working part-time to fund university. These other factors were not explored in this study.

Aligned with the findings that those students with a deep learning approach and low marks adopted a non-strategic approach, one reason for James only achieving 52% could be that James was not adopting a strategic approach to his learning. During the interview James displayed no evidence of adopting a strategic approach to his learning and there was very limited evidence of metacognition. For example, James over simplified the reason why he was failing FAC and noted that this was because he had studied alone rather than in a group. This concept of needing to study in a group could be linked to work by Treisman (referred to by Rollnick, 2005) who notes that students who study in groups not only share knowledge about the topic, but also about their understanding of what was being required of them by their lecturers and the University. A preference to study in a group is also a characteristic of an active learning style and students with a preference for an active learning style tended to get lower grades than those with a reflective learning style. The implications of certain learning style preferences are discussed further below.

In summary, James obtained 74% for matric mathematics and he believed that he was capable of doing better in the FAC course than his class marks indicated. There are a number of possible reasons for James not obtaining higher marks, some of which are evident from the interview: James had a low level of metacognition and did not follow a strategic approach to his learning; he followed a serialist strategy and as explained by Entwistle (in Schmeck 1988) may have run out of time to complete the process and thus omitted the stage of integrating the material; although James followed a deep approach there was no evidence that he had been able to abstract out the process required to master the FAC topics.

Kabelo obtained the fourth highest rating from the learning approach questionnaire. That is, according to the learning approach questionnaire Kabelo adopted a “very” deep learning approach. This is also largely in agreement with the findings from the interview. In addition, the interview also revealed that Kabelo adopted a strategic approach at times. For example, Kabelo noted that he would focus on the most important aspects when studying for a test, that he would ensure that he learnt what had been on previous past exam papers and that he would ensure that he learnt what he knew well so that he would get it correct in the exam. This appears to be a suitable learning approach, that is to both understand the material as well as focusing on what is required to pass the exams. The question then is, although Kabelo passed with 55%, why did he not achieve better marks

given his approach to learning. Some possible answers are evident from comments Kabelo made in the interview.

Kabelo obtained 79% for matric mathematics and like James believed that he was capable of doing better in the FAC course than his class marks indicated. Kabelo felt that one of the reasons he was not doing as well as he could, was because the English used was difficult and that he did not understand the questions and that the test questions were asking for written explanations rather than mathematical proofs. From the questionnaire it was evident that Kabelo had no prior computer exposure. This lack of prior computer exposure and lack of understanding of the language and terminology used in the discipline could indicate that Kabelo was struggling to gain epistemological access, as expounded by Morrow (1994), into the world of computers. This could be one of the reasons that Kabelo did not achieve better marks. However, as outlined by Entwistle and Ramsden (1983) as well as Entwistle (in Schmeck 1988) there are a number of reasons why a student adopting a deep approach may not reach a deep level of understanding of the material and may not succeed. Ideally these reasons, such as running out of time to complete the intended approach, would be explored through additional follow-up interviews with the students after the results of the examination were available. However this was beyond the scope of the study.

Kableo and James are both black. The results indicated that black students tend to adopt more of a deep learning approach than the non-black students. In addition, as noted earlier, the average FAC course mark for the black students was lower than that achieved by the non-black students. The reasons for these differences could not be determined from the research. Could it be that the black students were **not** adopting a deep approach and that the instrument measured how students **believed** they should be approaching their studies rather than how they were actually studying? Related to this, could it be that, due to differences in culture, the black students were giving answers they believed were "correct", whereas the non-black students were more open in providing the "wrong" answers. Or could it be that the black students **were** adopting a deep approach and **were** attempting to understand and engage with the material, but for reasons such as running out of time or not having the required study skills did not master the material and hence did not achieve good grades. It could be that due to a lack of prior computer exposure the black students had to expend an inordinate amount of time gaining epistemological access to the world of computers and algorithms.

Turning now to those students who used shallow approaches to their learning but obtained high marks. As to be expected, the profile obtained showed that these students placed an emphasis on passing the course. However, in addition, these students emphasised that although they found that they have to memorise most of what they learn, they do try and **understand** the material. A good example of a student who, according to the questionnaire followed a "very" shallow approach, but obtained a fairly good final mark of 62% was Gill. The question then is: what did Gill do that enabled her to get good marks although she adopted a predominately shallow learning approach?

Gill obtained the second lowest rating from the learning approach questionnaire, indicating that she used predominately shallow learning approaches. Analysis of the questionnaire and interview confirmed this. During the interview Gill emphasised many times that she only learnt what she needed to know for tests and exams. However, Gill had an advanced level of metacognition and adopted a highly strategic approach to her learning. In addition, Gill was able to identify the underlying structure of the material and was able to abstract out the processes to be applied. Gill adopted an algorithmic approach and focused on remembering solution methods. In essence, although Gill used strategies indicative of a surface learning approach, Gill was very strategic in her approach and this enabled her to obtain a reasonable course mark.

Like Gill, the excelling students also adopted a strategic approach to their learning. Although the two excelling students both adopted a deep learning approach where required, they had both adopted a strategic learning approach so at to maximise their marks. Duncan said that he memorised the methodology and terminology used by the FAC lecturer. This can be viewed as learning how to become a participant of the academic practices associated with the FAC discipline. Of the four struggling students interviewed, only one student, Kabelo, gave any responses that indicated a strategic approach to learning. As noted earlier James adopted predominately a deep learning approach. Maria adopted a shallow learning approach and Lindiwe a mixture of deep and shallow.

In summary, those students who expressed views displaying a deep approach to learning, but who obtained low course marks, showed a **non-strategic** approach to their studying. On the other hand, there was evidence that those students who used a shallow learning approach but obtained high marks were following a **strategic** approach to their learning,

for example Gill. The excelling students adopted predominately a strategic approach to their learning. They adopted a deep approach where required and a surface approach at other times.

Ideally higher education is about obtaining a deep understanding about the material. However, students have to demonstrate that they have acquired the knowledge and this is generally determined through course work and examinations. Therefore students need to take this into account when studying. In effect, in order to maximise marks, students need to adopt a strategic approach to learning.

McCune and Entwistle (2000) refer to a strategic approach and note that students who adopt the strategic approach are concerned with achieving grades that are as high as possible and are therefore organised in their studies and focus on time management and employing the "best" approach for the task at hand. The "best approach" will depend on a number of aspects including how the material will be examined. A degree of metacognition will enhance the student's ability to select the appropriate learning approach. However, with one exception - Gill, none of the interviewed students displayed any meaningful level of metacognition.

According to Ramsden (1992) metacognition is essential for success in higher education. Using Flavell's (in Dickson 1981) definition of metacognition as monitoring one's thinking, the appropriate use of learning approaches requires conscious decisions about "what to do and when", plus a continuous monitoring and reflection of how one's work is progressing. Using Morrow's (1994) concept of epistemological access, an understanding of the requirements of the particular discipline as well as higher education requirements are also essential. This all points to the necessity of the students adopting a strategic learning approach. However, lecturers are sending out a conflicting message, on the one hand requiring students to think deeply about what they are learning, but on the other hand requiring them to cover a large amount of material in a short time and subjecting them to timed tests which predominately test short term knowledge retention and call for shallow approaches. To meet these demands, students require a level of metacognition and knowledge of what is required by the discipline, that is they need to gain access to the discipline and learn how to "play the game". Based on this they will be able to adopt the most appropriate approach to obtain high marks.

From the interviews there are examples of the struggling students, (probably unconsciously), attempting to gain epistemological access to the FAC course. The struggling students were seeking out model answers to learn how to solve and answer the problems; they took out library books as the lecturer encouraged them to do so. However, it appears that these informal means of gaining epistemological access did not bring about success and it may be worthwhile for the lecturer to provide more formal assistance such as study skills for the FAC course and additional computer exposure. Although I have used the term "study skills", it is too "shallow" a concept and does not cover the entire essence of what students need to gain knowledge in. A better term may be "academic competence", where what I am referring to is the explicit exposition of the mores of the discipline.

Regarding learning styles, there were very few statistically significant correlations between any particular learning style and FAC course mark. On an interval scale reflective learners obtained higher course marks than active learners. The frequency of students per learning style category was examined. The large majority of the students had a preference for a visual learning style. More than 80% of the sample group were visual learners. Felder and Spurlin (2005) reported similar findings from other studies. This finding was also verified during the interviews. Gill, for example, explained that she used "spider diagrams" to remember her work. James noted that he liked drawing mind-maps and that he understood pictures better than words. Lindiwe emphasised that she tended to forget words and that she learnt from pictures. Unfortunately, even though the majority of students have a visual learning style preference, traditionally the predominant teaching style favours verbal learners (Felder and Spurlin 2005). From the interview with the lecturer of the FAC course it would appear that, as expected, his teaching style was predominately verbal. (Verbal refers to both the spoken and written word, whereas visual refers to pictures, diagrams, flow-charts, etcetera). Consistent with this, there is also some evidence that in the sample group, the small sub-group of verbal learners achieved higher grades than visual learners.

Interesting results were obtained on the active / reflective learning style dimension. There was statistically significant evidence that reflective learners obtained higher course marks than active learners. This was not unexpected as traditionally the predominant teaching style favours those with a preference for a reflective learning style. What was unexpected was the high number of reflective learners compared to other studies (Felder and Spurlin

2005). Over 60% of the sample population were reflective learners. Given the high percentage of black students in the sample compared to other studies the temptation could be to attribute this to racial differences. However, on further examination of the results it was evident that this was not the case as 70% of the white students were reflective learners and only 58% of the black students were reflective learners. From the interviews it was apparent that students understood the meaning of active and reflective learners and generally agreed with the preference determined from the ILS. Only one student, Kabelo, felt that he was more active than the ILS indicated, but it was evident from his comments that he was fairly reflective. I was therefore unable to explain why the research sample population displayed a different preference in the active / reflective dimension to that evident in other studies. Although learning styles are fairly consistent traits, it was remarkable to observe that Gill commented that her preference for an active or reflective style depended on the subject matter. Gill noted that she was not interested in group work (a characteristic of an active learner) if she knew a topic as it slowed her down, however she was happy to do group work in a topic she was battling with.

In the study there were some interesting relationships between learning styles and learning approach ratings. The more intuitive or global thinker a student is the deeper the approach the student adopts to learning. Instinctively these results are expected, but to-date no one had found evidence of it (Richard Felder, personnel communication, 18 March 2005). Due to the theoretical nature of the FAC course, it could be expected that intuitive learners (abstract thinker, orientated towards theories, principles and underlying meanings) would get higher grades than sensing learners. There was no evidence of this. However, of interest was the highly excelling student, Joseph, who had a reasonably deep learning approach and a fairly unique learning style profile: moderately reflective, moderately intuitive and moderately global.

8.5 Answers to Research Question

Three research questions were posed:

1. What are the various learning styles of students studying the FAC course?
2. What are the learning approaches used by students studying the FAC course?
3. What, if any, relationship is there between learning approaches, learning styles and student success?

These questions have been taken into account in all of the above discussions and no discussion of the results is provided below. The recommendations based on the discussions and findings are presented in section 8.7. In this section as succinct an answer as possible is provided for each question.

8.5.1 What are the learning styles of students studying the FAC course?

An overview of the learning styles of the sample group was obtained from the students' responses to the ILS. The results from the ILS were validated by the students interviewed. Comparable with other studies on the learning styles of engineering and science students (Felder and Spurlin 2005), a large percentage (81%) of the sample group are visual learners. A considerably larger percentage (62%) than that found in other studies are reflective learners (Felder and Spurlin 2005; Van Zwanenberg et al. 2000; Chen 2003). Figures in the 40% to 60% range for the sensing / intuitive dimension and sequential / global dimension are aligned with findings from a number of other studies (Felder and Spurlin 2005).

8.5.2 What are the learning approaches used by students studying the FAC course

As to be expected the learning approaches adopted by the students studying the FAC course ranged from a very surface approach to a moderately deep approach. From the learning approach questionnaire, the maximum rating obtained was 5.68, the minimum 2.72 and the mean was 4.48. The learning approach questionnaire did not differentiate those students who adopted a strategic learning approach. However, from the interviews it was apparent that both of the excelling students, both of the competent students and only one of the four struggling students expressed views that indicated that they followed a strategic approach to their learning.

Of interest, statistically significant differences were found in the average learning approach ratings of black students compared to non-black students, and female students compared to male students. Black students tend to adopt more of a deep approach than the non-black students. Females tend to adopt more of a surface learning approach and males more of a deep learning approach.

8.5.3 What, if any, relationship is there between learning approaches, learning styles and student success?

The first question explored was whether, within each learning style dimension, students who favoured one category or another performed better. The only statistically significant difference found was that, on an interval scale, reflective learners obtained higher FAC course marks than active learners. However, the general trend was that reflective learners scored higher than active learners; intuitive learners scored higher than sensing learners; verbal learners scored higher than visual learners and sequential learners scored higher than global learners. This pattern has been found in other similar studies (Thomas et al. 2002) and is aligned with the belief that lecturers in the engineering and science faculty follow a teaching style that favours those students who are reflective, intuitive, verbal and sequential (Felder 1993).

This trend was also evident on examining the groups of students as determined by the students' FAC course marks. It was clear that the top, excelling students were notably more reflective (89% vs 61%) and intuitive (78% vs 40%) than the overall sample. In addition, compared to the learning style profile of the entire sample group, the borderline / struggling students are notably more sensing (77% vs 57%) and slightly more sequential (65% vs 54%) than the overall sample.

No relationship was evident between the learning approach adopted by students and their FAC course mark. This is contrary to the findings of a number of earlier studies (Entwistle and Ramsden 1983; Ramsden 1992; Biggs 1987). From the learning approach profiles it was apparent that the students who adopted a deep approach to learning, but obtained low grades, were non-strategic. Some of the possible reasons for students adopting a deep approach to learning, but achieving low grades, including the role of a strategic learning approach, have been discussed above.

Returning to the original problem, why is there a high failure rate in the FAC course? It is evident from the answers to the research questions and the discussion in section 8.4 that the theoretical framework of learning styles can only provide some limited insight. The lecturer is probably not teaching to all the learning styles of the students, in particular to students with an active and visual learning style preference. It is also evident that the theoretical framework of learning approaches can only provide some limited insight, in particular that a strategic learning approach may be required to succeed. What appears to

be important is that students need to “learn how to play the game”. To do this students need to be sufficiently metacognitive to understand which learning approach to adopt. The students also need to learn how to be a participant in the social practice of “analysing and proving theories and algorithms”. Group work may assist students to understand what is required of them by the lecturer and the university (Treisman 1992).

8.6 Limitations

The limitations of the study have been raised and discussed throughout the report. In this section a few general limitations are highlighted.

To limit the scope of the study only two constructs were researched, namely learning styles and learning approaches. It is clear that the reason that students fail the FAC course is far more complex than this study could do justice to. In particular, a related concept, that of learning strategies, may provide some insight into why students fail the FAC course. The influence of demographic factors such as race could also add additional insights.

The sample population was limited to students in the 2004 academic year. Ideally the study would be repeated on another sample group. In this way the trends identified could be verified or refuted. In addition, due to the constraint to complete the study during 2004, no findings made during the study could be tested. For example, it would be meaningful to investigate whether modifying the teaching style to particularly accommodate active learners would have any effect on the average grades of active learners. This would be according to an action research design.

One of the weaknesses of the study was using instruments not specifically designed for computer science students. In particular the learning approach instrument had been designed for chemistry students. In addition the learning approach questionnaire could not measure if students adopted a strategic approach to their learning. However, in some cases it was possible to ascertain this from the interviews.

As a result of reclassifying the students interviewed, there were only black students in the struggling group and only white students in the competent and excelling groups. This left a number of unanswered questions. Do white struggling students follow a non-strategic learning approach, or only black struggling students? What would the competent black

students have answered in the interview? Of course the interview sample was very small, so even with a better mix of the groups, no firm conclusions could be made.

Due to the various limitations highlighted above, care must be taken neither to generalise the results inappropriately nor to transfer the results to situations that differ significantly from the research population.

8.7 Recommendations

Based on the literature reviewed, research findings and limitations of the study, the following recommendations, or items for consideration by the FAC lecturer and school of Computer Science at Wits, can be made.

The FAC lecturer should formulate a teaching approach that addresses the learning styles of all the students. This follows the advise of Felder (1996). In particular:

- In order to accommodate the learning style of the vast majority of the students, the lecturer should find ways to present some of the material in a visual manner. This may result in more effective learning by the visual learners as the instruction will be provided in a style consistent with their preference.
- In order to involve active learners the lecturer should encourage active learning (engaging students in class activities other than listening to lectures) and cooperative learning (getting students to work in small teams on projects or homework under conditions that hold all team members accountable for the learning objectives associated with the assignment) (Felder and Brent 2005).
- The FAC lecturer must continue to provide an opportunity for the students to think through the material by themselves as, based on the sample group, a large number of the FAC class are likely to be reflective learners.

Following on the recommendations of Case and Gunstone (2002) the FAC lecturer should match the workload and assessment methods with the desired learning approach of the students. In the past the FAC lecturer has encouraged the students to adopt a deep learning approach. However, heavy workload and time pressures in assessments could be detrimental to this development. There is evidence from the interviews that successful students adopted a strategic learning approach and focused on what needed to be learnt and understood to be successful in the formal assessments.

"Academic competence" should be taught to the students. This would need to include elements of strategic learning and may be partially contrary to what the FAC lecturer wishes to achieve. Case and Gunstone (2002) argue that the promotion of metacognitive development should be integrated with the content matter that students are studying. The view is that students are not able to transfer the skills from one context to another. This view is supported by McCune and Entwistle (2000) who comment that "effective advice should ideally take into account the more idiosyncratic and dynamic aspects of studying, and the specific academic discourse and learning contexts within which the students are operating" (McCune and Entwistle 2000 pg 15). In this manner the students would be assisted in gaining epistemological access to the FAC discipline.

Aligned with the need to assist with the students gaining epistemological access, the FAC lecturer needs to pay attention to terminology used. In the interviews a number of students raised the issue of language. This is supported by the views of Yahya (1992). It may be useful to provide a glossary of terms or to give the students an opportunity to learn the new terminology. In addition, the FAC lecturer needs to ensure that assessment questions are testing an understanding of the FAC principles rather than the level of English competence.

Finally, the objectives of the Computer Science course need to be clearly communicated to potential students. Although students are discovering early on in the course that the study of computer science differs from their expectations, it would be better if students could be made aware of this prior to registering for the course. The feasibility of introducing some exercises in orientation week to provide some ideas to the students of the nature of Computer Science should be investigated.

Although a number of insights have been gained through the study, no study is ever complete. In the next section a few ideas on additional research that could be undertaken are sketched.

8.8 Future Directions

Based on aspects identified during the review of the literature and the research results a few ideas for future research are provided below. The areas for future research have been

constrained to areas that would assist in identifying why there is a high failure rate in the FAC course. There are many other research questions within the theoretical frameworks of learning styles and learning approaches. Some of these questions are highlighted by Felder and Brent (2005), for example: Do any learning style preferences or learning approaches adopted depend on students' ethnic and cultural backgrounds? To what extent does teaching to accommodate students' learning style preferences improve the students grades?

As noted in the previous section, one of the weaknesses of the study was using an instrument designed for chemistry students to measure the learning approach of FAC students. A study similar to that undertaken by Booth (1992) that seeks to uncover the specific learning approaches present within FAC would be worthwhile. The interview with the students could be expanded upon. In addition to asking students how they go about studying for the FAC course, the students could be given a problem to solve. The researcher could observe how they approach the solving of the problem and particular questions on the approach they adopted could be asked. This would take into account the slightly different way that the word "approach" is used by Booth (1992). In contrast to how the term approach is used in this report to refer to the intention of the students as well as the process and overall strategy they followed (whether consciously or not), Booth's use of "approach to writing a program" refers to a "student's first encounter with a problem and the immediate way in which the student goes about producing a program from the result of the encounter" Booth (1992, pg 233).

The concept of a lack of epistemological access (Morrow 1994) is referred to in the above discussion as a possible reason for some students not succeeding in the FAC course. This concept could be investigated in greater detail. From a similar perspective, alienation and engagement (Case 2004b) could be an appropriate theoretical framework to further research some of the possible reasons for the high failure rate in the FAC course.

The nature of the teaching that the students are getting could be investigated. The Course Perceptions Questionnaire (CPQ), recommended by Felder (personal communication, 19 June 2004), is one way to do this. In addition the lecturer could be observed in lecture and tutorial situations. This would enable relationships between learning styles, learning approaches and the learning environment to be investigated.

Within the overall research aim of understanding why students fail the FAC course and what the lecturer can do to improve teaching and in a field as rich as learning styles and learning approaches there are many other aspects that could be investigated.

8.9 Final Words

In the words of Entwistle and Ramsden (1983, pg 4-5) “many of the findings of this research have immediate relevance to lecturers who wish to improve their teaching, and for students who want to improve how they study. There are also important implications for increasing the efficiency of learning in the costly business of higher education”. Based on the aims of the study, the focus of the recommendations have been on what the FAC lecturer can do to take account of the learning preferences of the students and to assist the students in adopting the appropriate learning approach. I trust that the FAC lecturer will get value from this study and adapt his teaching approach where prudent with the positive result of improved performance by the students in the FAC course at Wits.

APPENDICES

LEARNING APPROACH "MODELS" APPENDIX A

Table A1 Students' Orientations to Higher Education (Entwistle in Schmeck 1988, pg 23)

Educational Orientation	Aim	Concerns
Vocational		
Extrinsic	Obtaining a qualification	Perceived worth of qualification
Intrinsic	Being well trained	Relevance to future career
Academic		
Extrinsic	Progression up the educational ladder	Academic progress and performance
Intrinsic	Pursuing subject for its own sake	Choosing stimulating courses or topics
Personal		
Extrinsic	Compensation for past failures	Reassuring comments and pass marks
Intrinsic	Broadening horizons	New insights and challenges
Social		
Extrinsic	Having a good time	Facilities for sport and social activities

"Educational orientation derives from the work of Taylor and describes the set of values and attitudes relating to education which the person holds at a particular time" (Entwistle in Schmeck 1988, pg 22).
"Intrinsic" is used to indicate that satisfaction is derived from the course content itself.
"Extrinsic" refers to institutionalised aspects of the course.

Table A2 Motive and strategy in approaches to learning and studying (Biggs 1987, pg 11)

Approach	Motive	Strategy
Surface	Surface Motive is instrumental: main purpose is to meet requirements minimally: a balance between working too hard and failing.	Surface Strategy is reproductive: limit target to bare essentials and reproduce through rote learning.
Deep	Deep Motive is intrinsic: study to actualise interest and competence in particular academic subjects.	Deep Strategy is meaningful: read widely, inter-relate with previous relevant knowledge.
Achieving	Achieving Motive is based on competition and ego-enhancement: obtain highest grades, whether or not material is interesting.	Achieving Strategy is based on organising one's time and working space: behave as 'model student'.

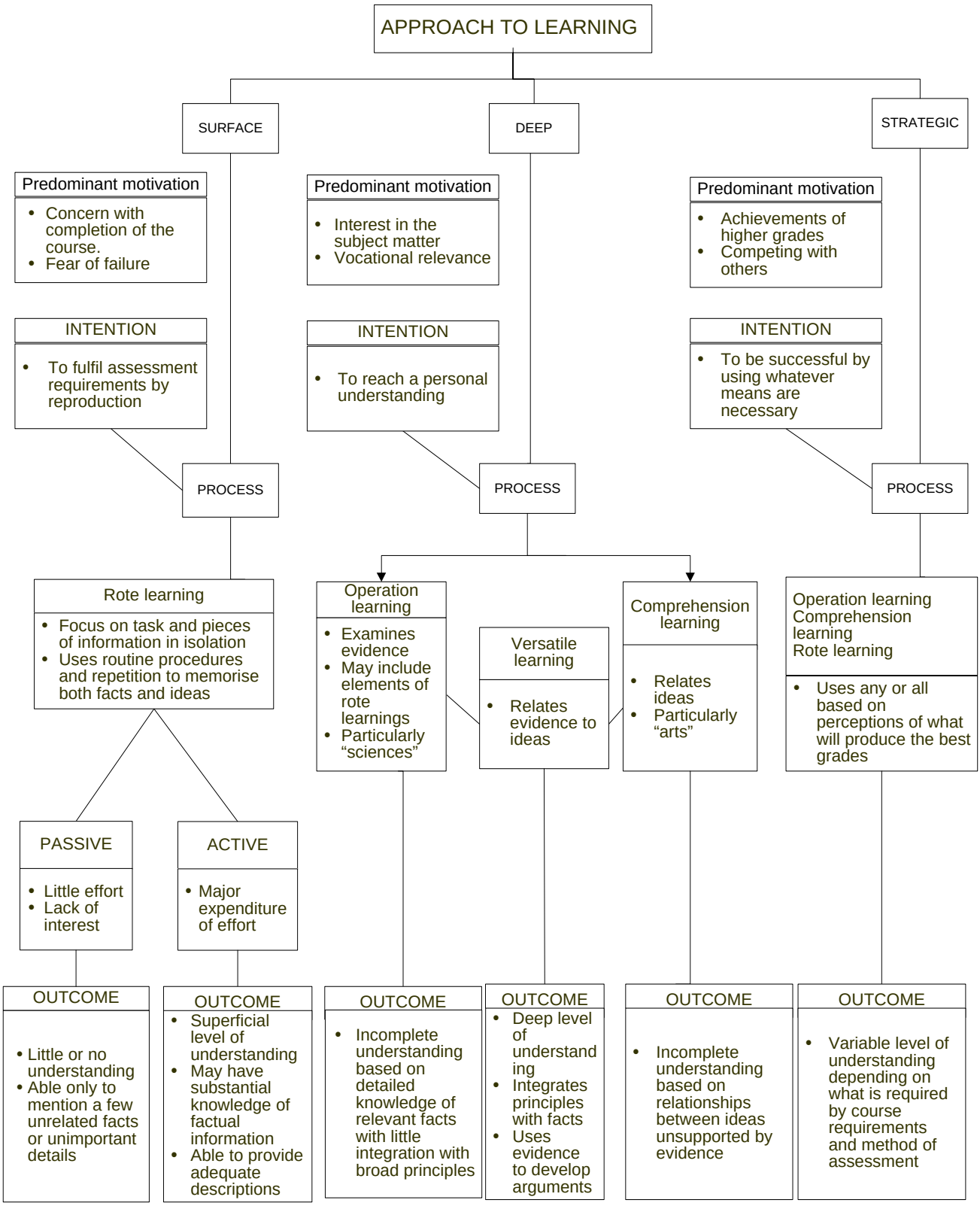

Figure A1 A model of the relationship between motivation, process and outcome (Entwistle in Schmeck 1988, pg 46-47)

Table A3 Rubric for rating student responses to the Learning Approach Questionnaire (Rollnick)

Level	Descriptor
1	Rote learning; external control; exam orientated; unable to see any other point in study; trying to impress marker; looking for/expecting one right answer; memorizing only; cramming; no self-reliance.
2	Relies heavily on being given information; little clear intrinsic interest in study; aims for good marks; sees the teacher as the authority; feels insecure with ambiguity; prefers shortcuts to investing real time.
3	Trying to co-operate; some conscientiousness; lacks independent approach; some attempt to manage time; finds studying stressful; likes a structured approach; understands learning in terms of quantity (rather than quality).
4	Tries to develop strategies; is prepared to engage in new material within clear boundaries; distinguishes between rote learning and understanding; sees the value of learning.
5	Is motivated to succeed; understands the value of own ideas; is prepared to question other's ideas; looks for evidence; tries to build own frameworks.
6	Sees knowledge as intrinsically empowering; monitors own understanding; has well developed time-management and study strategies; confident; can distinguish between different kinds of knowledge and also different purposes for studying.
7	Loves learning; enjoys independent creativity and discovery; expects to be challenged; is clearly in control of own learning; copes easily with ambiguity and complexity.

UNIVERSITY OF THE WITWATERSRAND

MASTERS IN SCIENCE EDUCATION RESEARCH PROJECT

Dear Computer Science Students

I am conducting my Masters research in the field of Science Education, in particular Computer Science Education, for example studying how to teach computer science and how students learn when studying computer science. For my research project I am studying how students study the Fundamental Algorithmic Concepts (FAC) course.

I would appreciate it if you would participate in this research project by completing the attached questionnaire. However, your participation is **completely voluntary.** If you do not wish to complete the questionnaire, then you are under no obligation to do so. If you do not participate, you will **not** be penalized in any way. Once you start, you may stop participating at any time.

If you do choose to participate, whatever you say will remain confidential. The information gained will be used anonymously and no student numbers or names will be used in any reports. None of what you say will be fed back to your lecturer and the information gathered will in no way affect your marks or be used against you in any way. All information gained will be kept in the strictest confidence and will not be used for any purpose other than research and improving the FAC course.

Please feel free to contact me if you would like to know more about the research. I can be reached on 011 638 3125.

Thanks you for your assistance. Your time and effort is appreciated and will be of value to the research.

With thanks

Linda Wedderburn
Masters student

UNIVERSITY OF THE WITWATERSRAND

School of Computer Science

MASTERS IN SCIENCE EDUCATION RESEARCH PROJECT

Consent Form

Student Number: ……

Name: ……

I have read and understood the Research Project Information sheet.

I am willing to participate in this study.

Signed: ……

Date: ……

UNIVERSITY OF THE WITWATERSRAND

School of Computer Science

Learning Styles and Study Approaches Questionnaire

STUDENT NO:	
SURNAME:	**NAME:**

INSTRUCTIONS:

1. Please write your name and student number in the boxes above.
1. This questionnaire is divided into four parts. Each part is in a different colour. Please give responses to all the parts.
2. There are **NO** correct answers so please respond by giving your own honest opinion.
3. Please answer every question.
2. Please work your way through the questionnaire quite **quickly**.

Part A: Demographics

1. Age: _____

2. Sex: Male ☐ Female ☐

3. What language(s) do you mainly speak at home? : _____

   _____

4. Where is your home (where your family lives)? _____

5. How would you describe your home area – as a city, small town, farm or traditional rural area?

   _____

6. Have your parents or any of your immediate family studied at University? _____

7. Please list your parents' occupations: _____

8. Please give the name of the School you studied at: _____

9. How would you describe your school (government, private, inner city, township, rural,)

   _____

11. What was your matric mark for maths? : _____

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Part B: Computer Background

Please put a tick (√) in the box that corresponds with your answer.

Computer Exposure

1. Before coming to university, had you used a computer? Yes ☐ No ☐
2. Before coming to university, had you programmed? Yes ☐ No ☐
3. Did you take Computer Studies as a matriculation subject? Yes ☐ No ☐
4. Do you have access to a computer outside university? Yes ☐ No ☐
5. Have you ever been employed in IT or computer science related jobs? Yes ☐ No ☐

Reasons for studying Computer Science

1. Do you plan to major in Computer Science? Yes ☐ No ☐
2. What are you interested in learning about in the Computer Science course?
   a. how to use a computer Yes ☐ No ☐
   b. a word processing package Yes ☐ No ☐
   c. spreadsheets Yes ☐ No ☐
   d. algorithms Yes ☐ No ☐
   e. data structures Yes ☐ No ☐
   f. how to program Yes ☐ No ☐
   g. hardware Yes ☐ No ☐
   h. networks Yes ☐ No ☐
   i. database design Yes ☐ No ☐
   j. artificial intelligence Yes ☐ No ☐

STUDENT NO:

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Part C – Index of Learning Styles

This instrument is used to assess your preference on four dimensions of a learning style model developed by Richard M. Felder and Linda K. Silverman. The technique involves asking you 44 short questions. Each question has two options (a) or (b).

- Please ring your answer (a) or (b) for each question.
- Please choose only one answer for each question. If (a) and (b) seem to apply to you, choose the one that applies more frequently.
- There are **no** correct answers so please respond by giving your own honest opinion so that your answers will **accurately** describe your **learning style.**
- Please answer every question.

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

2. I am more likely to be considered
a) realistic.
b) innovative.

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

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

5. When I am learning something new, it helps me to
a) talk about it.
b) think about it.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

34. I am more likely to be considered
- **a)** sensible.
- **b)** imaginative.

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

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

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

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

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

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

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

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

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

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

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Part D – Study Approaches Questionnaire

This questionnaire has been designed to allow you to describe how you go about learning and studying. The technique involves asking you a number of questions. The items are based on comments made by other students. Please respond by giving your own honest opinion, so that your answers will **accurately** describe your **actual** ways of studying the FAC (Fundamental Algorithmic Concepts) course. Work your way through the questionnaire quite **quickly**.

SECTION A

Consider each of the statements carefully, and circle the one that best fits your own opinion.

1. To me the term *'LEARNING ' means*

A. Making sure I remember things well.

B. Developing as a person.

C. Building up knowledge by acquiring facts and information.

D. Being able to use the information I have acquired.

2. My reason for entering higher education is that:

A. This qualification will enable me to get a good job.

B. It will give me another three or four years to decide what I really want to do.

C. I will be able to study subjects in depth, and take interesting courses.

D. I will have an opportunity for an active social life and/or sports.

E. My parents wanted me to come.

SECTION B

Decide whether you agree or disagree with the statement, then circle the one that best fits your own opinion. If none of the options suits your point of view, complete section X

1. I gear my studying closely to what seems to be required for tests and exams.
   A. I agree with this statement because passing is most important for my future.
   B. I agree with this statement because knowing too many things can lead to failure
   C. I disagree with this statement because I study to pass but I also try to learn beyond this.
   D. I disagree with this statement because I try to avoid cramming for the exam only.
   E. I disagree with this statement because I will never know what is in the exam.
   X. None of the above expresses my point of view which is

   ……
   ……

2. I like to be told precisely what to do in FAC tut/lab sessions
   A. I agree with this statement because when I present my work I would like it to be what the lecturer wants and not waste time.
   B. I agree with this statement because I have to know exactly what I need to do to pass
   C. I disagree with this statement because I like to do things on my own and express myself freely.
   D. I disagree with this statement because if I am always told what to do I will never learn to solve problems.
   X. None of the above expresses my point of view which is

   ……
   ……

3. I usually go over the work I've done in FAC tut/lab sessions to check the reasoning and see that it makes sense.
   A. I agree with this statement because I check to see that I have not made mistakes
   B. I agree with this statement because I need to make myself clear so that another person can understand
   C. I agree with this statement because checking is important so I can get higher marks
   D. I agree with this statement because checking gives me confidence that I have done it well
   E. I disagree with this statement because checking can be time consuming
   X. None of the above expresses my point of view which is

   ……
   ……

4. Often I find myself questioning things I hear in class or read in books.

   A. I agree with this statement because you cannot trust everything you hear, you have to form your own opinion
   B. I agree with this statement because I may have misunderstood what I read or heard
   C. I agree with this statement because questioning helps you to understand
   D. I disagree with this statement because different opinions confuse me
   E. I disagree with this statement because books and teachers are reliable sources
   X. None of the above expresses my point of view which is

   ……
   ……

5. When I am studying, I stop from time to time to think about what I am trying to learn.

   A. I agree with this statement because I want to make sure I remember
   B. I agree with this statement because I want to know if what I am learning makes sense
   C. I agree with this statement because then I don't just learn it off by heart
   D. I disagree with this statement because stopping from time to time is time consuming
   E. I disagree with this statement because stopping from time to time is confusing
   X. None of the above expresses my point of view which is

   ……
……

6. I work steadily through the term, rather than leave it all until the last minute.

   A. I agree with this statement because I don't work well under pressure
   B. I agree with this statement because leaving it till the last minute makes the job bigger
   C. I agree with this statement because I like to learn, not just pass
   D. I agree with this statement because at the last minute you will confuse yourself
   E. I disagree with this statement because I forget everything if I start too early
   X. None of the above expresses my point of view which is

   ……
   ……

7. I usually plan out my week's work in advance, either on paper or in my head.

A. I agree with this statement because planning helps me remember what to do
B. I agree with this statement because it helps to manage time and work hard
C. I agree with this statement because planning keeps you in control
D. I disagree with this statement because usually when I plan I tend not to do it
E. I disagree with this statement because unexpected events happen
X. None of the above expresses my point of view which is

……
……

8. I like exams or tests which need only the material given in our notes.

A. I agree with this statement because this makes studying easier: you know what is required.
B. I agree with this statement because I will be sure to pass and the exam is a measure of my knowledge.
C. I disagree with this statement because I would then not know the value of other general things
D. I disagree with this statement because I like challenges and being able to give my opinion and show my understanding
X. None of the above expresses my point of view which is

……
……

9. I like teachers who tell us exactly what to put down in our notes.

A. I agree with this statement because you have a summary of what you are learning
B. I agree with this statement because teachers know what they are doing
C. I agree with this statement because it makes the work easy
D. I disagree with this statement because it does not allow me to understand for myself
E. I disagree with this statement because I don’t like spoon feeding
X. None of the above expresses my point of view which is

……
……

10. I like exams that allow me to show that I've thought about the subject for myself.

A. I agree with this statement because it tests if I understand my work
B. I agree with this statement because it shows how much I can do
C. I agree with this statement as long as it contains what I have been taught
D. I agree with this statement because it is the time when I can apply my knowledge
E. I disagree with this statement because exams should test what I know
X. None of the above expresses my point of view which is

……
……

11. I like books that challenge you, and that provide explanations that go beyond the lessons.

A. I agree with this statement because I get deeper knowledge
B. I agree with this statement because learning is not only about exams
C. I agree with this statement because it adds on to what you get from the teachers
D. I disagree with this statement because extra material only confuses you
E. I disagree with this statement because I don't like irrelevance
X. None of the above expresses my point of view which is

……
……

12. I like books that give you clear information, which can easily be learned and remembered.

A. I agree with this statement because it helps to get more marks and information
B. I agree with this statement because it saves time
C. I agree with this statement because it makes studying easy
D. I disagree with this statement because easy things make you lazy
E. I disagree with this statement because I want to be able to formulate my own views
X. None of the above expresses my point of view which is

……
……

13. Often I find myself wondering if my academic work is really worthwhile.
    A. I agree with this statement because even with a degree in SA now, I may end up unemployed
    B. I agree with this statement because even though I work hard I sometimes don't get good marks
    C. I disagree with this statement because learning helps me to develop as a person no matter what the result
    D. I disagree with this statement because I strongly believe in myself and know I will succeed.
    E. I disagree with this statement because I don't waste time wondering, I spend time studying
    X. None of the above expresses my point of view which is
    ……
    ……

14. I find I have to memorize most of what I have to learn.
    A. I agree with this statement because I try to understand first and memorize later
    B. I agree with this statement because if I keep memorizing it will help in the exams
    C. I agree with this statement because memorizing helps me learn faster
    D. I disagree with this statement because it is more important to understand than to memorize.
    E. I disagree with this statement because if you enjoy what you learn you remember it anyway
    X. None of the above expresses my point of view which is
    ……
    ……

15. I try to link some of the ideas I come across to other subjects whenever possible.
    A. I agree with this statement because it gives me a better idea of how things work
    B. I agree with this statement because all subjects are related
    C. I agree with this statement because there is more than one way of knowing things
    D. I agree with this statement because finding links helps keep track of all subjects
    E. I disagree with this statement because although it is a good idea it is difficult to do
    X. None of the above expresses my point of view which is
    ……
    ……

16. I tend to read very little beyond what is actually required for passing.

A. I agree with this statement because if you read too much you lose focus: it is best to stick to the facts
B. I disagree with this statement because learning is not just about passing but about understanding and application.
C. I disagree with this statement because only when you read more deeply do you see the value in it.
D. I disagree with this statement because reading more improves my marks in the exam.
X. None of the above expresses my point of view which is

……
……

17. I think it is most important to spend my time learning the information I have to know to pass.

A. I agree with this statement because I have to grasp and focus on those parts that will help me pass.
B. I agree with this statement because I want to pass but also spend time with my family or play sport
C. I agree with this statement because learning about other things that don't help my exam mark is a waste of time.
D. I disagree with this statement because learning is about broadening the mind not just passing.
E. I disagree with this statement because I want to do as well as possible not just pass.
X. None of the above expresses my point of view which is

……
……

18. I find FAC relevant.

A. I agree with this statement because I learn how to analyse and apply algorithms
B. I agree with this statement because everything has a purpose.
C. I agree with this statement because the underlying structure of programming is shown
D. I agree with this statement because it helps me develop the way I think
E. I disagree with this statement because it won't help me become a better programmer.
X. None of the above expresses my point of view which is

……
……

19. Much of what I'm studying in FAC makes little sense as a whole: it's like unrelated bits and pieces.
    A. I agree with this statement because FAC is based on concepts and ideas and it is difficult to understand things that can't be visualised.
    B. I agree with this statement because FAC is not my favourite subject therefore I do not spend enough time studying it
    C. I agree with this statement because information is fragmented and has no links
    D. I disagree with this statement because it fits together when you do data structure and other courses.
    E. I disagree with this statement because each sub-section adds onto another sub-section
    X. None of the above expresses my point of view which is

    ……
    ……

20. When I learn how to do direct proofs I practice a number of examples from the course notes and lab/tut session.
    A. I agree with this statement because I develop a method and do not have to learn proofs off by heart
    B. I agree with this statement because they are what you need to do to pass the course.
    C. I agree with this statement because practice makes perfect.
    D. I agree with this statement because it expands my understanding.
    E. I disagree with this statement because direct proofs are all of a similar structure so not much practice is required.
    X. None of the above expresses my point of view which is

    ……
    ……

SECTION C

How well do you think you're doing in FAC? Please rate yourself objectively, based on the marks you have been obtaining. Circle the level you think is correct for you.

Very well		Quite well		About average		Not so well		Rather badly
9	8	7	6	5	4	3	2	1

Is this different from your potential? If there is a difference, explain why.

……
……
……..

UNIVERSITY OF THE WITWATERSRAND

School of Computer Science

Learning Styles and Study Approaches Questionnaire

SPOKEN INSTRUCTIONS

FOR PILOT GROUP

1. Thank you for your time.

2. The objective is to complete the questionnaire that has been given to you to help a Masters Student pilot the questionnaire on learning styles and learning approaches. A pilot is a way of trying out a questionnaire before it is given to the intended group.
3. The questionnaire is intended for first year FAC students. So where there is a question that relates to FAC, please think back to the course you did last year.

4. Do you all have a questionnaire?

5. Please read the information letter and consent form. Your participation is voluntary and all information will be kept confidential. Please sign the consent form if you are happy to give your consent.

6. Please write your name and student number in the boxes on the front page.
7. This questionnaire is divided into four parts. Each part is in a different colour. Please give responses to all the parts.
8. There are **NO** correct answers so please respond by giving your own honest opinion.
9. Please answer every question.
10. Please work your way through the questionnaire quite **quickly**.
11. Please choose only one answer for each question. If more than one seems to apply to you, choose the one that applies most frequently.

UNIVERSITY OF THE WITWATERSRAND

School of Computer Science

Learning Styles and Study Approaches Questionnaire

SPOKEN INSTRUCTIONS

1. Thank you for your time.
2. I believe that **your** views will contribute to the Masters study I am doing on learning styles and learning approaches.

3. Do you all have a questionnaire and an information letter?

4. Please read the information letter and consent form. Your participation is voluntary and all information will be kept confidential. Please sign the consent form if you are happy to give your consent.

5. Please write your name and student number in the boxes provided.
6. This questionnaire is divided into four parts. Each part is in a different colour. Please give responses to all the parts. Your student number is required for each part.
7. There are **NO** correct answers so please respond by giving your own honest opinion.
8. Please answer every question on the coloured pages. Answering all the demographic questions (Part A – white page) would be useful, but if you are uncomfortable about any question in Part A you do not need to answer it.
9. Please work your way through the questionnaire quite **quickly**. The questionnaire should take between 20 and 30 minutes.
10. Please choose only one answer for each question. If more than one seems to apply to you, choose the one that applies most frequently.

UNIVERSITY OF THE WITWATERSRAND

Masters in Science Education Research project

Interview Schedule

1. INTRODUCTION

- Good morning _____ (confirm spelling and pronunciation)
- Thank you very much for giving your time for this chat.
- I appreciate it very much, especially with the exams so close.
- My name is Linda Wedderburn.
- I studied Computer Science at Wits a lonnnng time ago. I did honours in Computer Science in 1984.
- In 2000 I started my masters in Science Education, but put it on hold for 2 years for work and family reasons and am now working to complete it this year by doing my research project.
- I believe that **your** views will contribute to the study I am doing on learning styles and learning approaches.

2. CONFIDENTIALITY & VOLUNTARY

I would like to go over what was in the consent form you signed

- Whatever you say will remain **confidential**.
- I may like to quote you, but I will not use your name, I will use a made up name.
- I am not a member of staff and none of what **you** say will be fed back to **your** lecturer and the information gathered will in no way affect **your** marks.
- The information will be used for research only.
- Your participation is **voluntary** and you may **stop** the chat at any time.
- If you do not participate you are **not** penalised in **any** way.
- I will use a tape recorder so that I can remember what you said.
- I also tend to think better with a pen in my hand, not sure why, so I may make some notes as we go along.
- Before we start, do you have any questions?

3. WARM-UP QUESTIONS

1. Thank you for participating in the survey.
2. I would like to just check the demographics that I have. (I will choose a few items to confirm from the questionnaire)

3. What courses are you studying this year?

o
o
o
o

4. Which course do you like the most? _____
    a. WHY?
    _____
    _____

5. Which course do you like the least? _____
    a. WHY?
    _____
    _____

6. Why did you choose to study Computer Science?
    _____
    _____

7. How do you think you will use Computer Science once you have completed your degree?
    _____
    _____

8. Are you studying / learning in Computer Science what you thought you would? **YES / NO**
    a. If NO, what is different?
    _____
    _____

4. LEARNING STYLE

1. Do you agree with the results of the Index of Learning Styles (ILS)?
Show the student where he/she is on each dimension of the LSI and ask for his/her comments on each dimension.

Definitions	DIMENSIONS		Definitions
Do it	***Active***	***Reflective***	Think about it
Learn facts	***Sensing***	***Intuitive***	Learn concepts
Requires Pictures	***Visual***	***Verbal***	Require reading or lecture
Step by step	***Sequential***	***Global***	Big picture

1. **Active / Reflective:** Agree / Disagree
   Comments:
   _____
   _____
   _____

2. **Sensing / Intuitive:** Agree / Disagree
   Comments:
   _____
   _____
   _____

3. **Visual / Verbal:** Agree / Disagree
   Comments:
   _____
   _____
   _____

4. **Sequential / Global:** Agree / Disagree
   Comments:
   _____
   _____
   _____

5. LEARNING APPROACHES

1. What sort of things do you do when studying the FAC course and why?
   (Probe question: If you had a test tomorrow what would you do today to prepare for it)

2. What do you do to prepare for the exam question on inductive proofs?

3. How do you study for a question on graph theory compared to how you study for a question on algorithms?
   (Probe questions: How do you study graph theory?
   How do you study algorithms?)

General probe questions:

- What do you mean by that?
- Can you please give me an example?

6. CONCLUSION / CLOSE-OFF

- Thank you very much for giving your time and for participating in this interview. I appreciate it very much.
- I will use the tape recorder to transcribe (write down) parts of what we have discussed and I will give this back to you to read, to check that you are happy with what I have written. I will remove anything you are not happy with.
- Do you have any questions you would like to ask me?

- I wish you everything of the best as you prepare for the exams.

APPENDIX H

Diary of interview events

A diary of the events associated with the interview process is outlined below.

- **Monday 17 May:** Set up a pilot interview for Weds 19 May 2004.
- **Tuesday 18 May**: Set up interviews with six "struggling" students.
- **Wednesday 19 May:** Pilot interview conducted.
- **Friday 21 May:** Sent an sms to all students confirming time of our discussions (interviews) as well as venue and asked them to advise via my cell phone if they could not attend. I received 2 confirming replies from students via sms.
- **Friday 21 May:** Set up an appointment with the excelling student.
- **Saturday 22 May:** I partially transcribed the pilot interview and assessed the ease of classifying the responses. I made note of what had been learnt.
- **Monday 24 May in the morning:** Phoned four students to confirm date, time and venue for interviews on Tuesday 25 May. One student advised that he did not think he could make the appointed time as he had a lecture at the specified time. We rescheduled the interview for Friday 28 May.
- **Monday 24 May early evening:** Sent an sms to the three students being interviewed on 25 May 2004 so that they had easy access to the time and venue for the interview.
- **Tuesday 25 May:** Interviewed three students.
- **Wednesday 26 May early evening:** I phoned the three struggling students to confirm the appointments for Friday 28 May and based on experience gained enquired if it was possible to move the appointments forward, that is closer together. This was possible for all the students. I did not phone the excelling student as I had only made the appointment with him on Fri 21 May and did not need to move his appointment as it was later in the day.
- **Thursday 27 May approx 8pm:** Sent an sms to the four students for the interviews on Friday 28 may so that they had easy access to the time and venue for the interview
- **Friday 28 May:** Interviewed four students
- **Saturday 29 May**: I sorted out the tapes and made copies of the tapes for back-up purposes. I found that I had not taped the interview with the excelling student. When I thought I turned on the record button, I had turned on the play button and this was not noticed. I thought of re-interviewing the student, but decided against this as a second interview could bias the results. I decided to use an alternative method of

recording the results of interviews and wrote notes based on memory. I wrote brief notes on each of the other interviews, expanding on the few notes I had taken during the interview.

- **Week of 31 May**: I contacted the excelling student and explained the situation and asked if he would check my notes. Fortunately the student had access to email so I emailed my notes to him, which he commented on and returned to me within 24 hours. He made the following comment regarding my notes: “generally, I think it’s a great reconstruction of our discussion, but there are a few minor additions.” His comments were checked and added to my notes where appropriate.

INTERVIEW TRANSCRIPTION **APPENDIX I**

INTERVIEWER: Linda Wedderburn
INTERVIEWEE: Lindiwe (pseudonym)

Question 1

Linda The next student I'm going to interview at 1 O'clock is Lindiwe.

(introduction)

Lindiwe Yeah

Question 2

Lindiwe Okay

Lindiwe Yes, its fine (to use tape recorder)

Lindiwe No questions

Question 3

Linda You answered the questionnaire, thank you for that, what I'd like to do, is just check that I've got the correct impression from that. Okay, you didn't provide your age which I understand because you're a female (both laugh), are you happy to provide it at all?

Lindiwe Yes its okay

Linda Okay, how old are you?

Lindiwe I'm turning 21

Linda 21, you're 20 at the moment?

Lindiwe Yes

Linda When is your 21st?

Lindiwe In November

Linda Its nice to turn 21, its special. Your home language is SeTswana and English, you're from Botswana

Lindiwe Yes

Linda And your mom or dad's a teacher? And you went to a private school?

Lindiwe Yes

Linda And you say you got a 3 for maths, do you know what that means, what sort of percentage roughly is it 3, 50, 60, 70, 80 percent?

Lindiwe Em I don't know the exact percentage but, I really don't know, because a 4 is, I don't know, 4 is above 64 and I don't know what a 3 is I really don't know *(The reason that the student does not know her percentage is because they write the Cambridge Local Examination syndicate exams in Botswana and the grades are 1 (highest) to 9 (lowest). The grades shift and the syndicate does not reveal the percentage equivalents. 6 is the lowest for a pass. 1 and 2 are sometimes converted to "A", and 3 & 4 to "B". 3 is quite good.)*

Linda Is it below 64 or above 64?

Lindiwe No, its above 64, I guess, I think it might be maybe 70, I'm not sure

Linda Okay, so its about 70%. And was it Higher grade or Standard grade?

Lindiwe Em, I don't know if its Higher grade or Standard grade, I did Higsce *(There is no higher or standard grade. The exam used to be the O level in the UK.)*

Linda Higsce, okay thank you.

Linda What courses are you studying this year?

Lindiwe I'm doing Comp Sci

Linda Computer Science

Lindiwe And Maths major, and Economics and Business Accounting

Linda Which course do you like the most?

Lindiwe I like Computer Science [xxx] but its difficult, its not really that difficult, just that you need a lot of time to study it

Linda Okay. Why do you like it the most?

Lindiwe Because I like computers

Linda What do you like about computers?

Lindiwe I'm busy studying, I saw it, I didn't read about it, about artificial intelligence, and I find that really interesting. And generally just, you can surf the internet.

Linda When you say you can surf the internet. Do you like the internet?

Lindiwe Yes

Linda What do you like about that?

Lindiwe There are lots of things which you can find on the internet, even though some of them are not true but some things are really interesting.

Linda Okay. And which course do you like the least?

Lindiwe Business Accounting

Linda And why do you like that the least?

Lindiwe Because I cant grasp, sometimes I can't grasp what we are supposed to do then its like if I'm doing the simple question today I tend to think beyond that, then I sometimes get the answer wrong, so I don't know [xxxxxx].

Linda And why did you choose Computer Science?

Lindiwe Basically, besides the money, back home its one of the few jobs that are not congested and I'll [xxxxx]. It would be a good opportunity for me to study Computer Science [xxxx]

Linda Okay And what do you think you will do with it when you finish your degree in Computer Science

Lindiwe No I'm not sure yet. I don't know.

Linda And are you studying in Computer Science what you thought you would?

Lindiwe I beg your pardon?

Linda Are you studying in Computer Science what you thought you would study?

Lindiwe No

Linda And what did you think you would be studying?

Lindiwe I thought I would be studying, … okay we will be taught about stuff like HTML.

Linda Okay

Lindiwe Yeah we are kind of, yeah we are, and just the basic stuff about computers and I thought we would be writing programs, [xxx] oh but we are, but I didn't think we would use Scheme.

Linda What did you think you would use?

Lindiwe I thought we were going to use, [xxx] Java or something, but Scheme is okay, its quite user friendly.

Linda Are you happy with what you're studying in Computer Science then, if it is not what you thought it was going to be?

Lindiwe But its okay, its interesting.

Linda Thank you

Question 4

Linda One of the parts, the questionnaire you answered, the question with the number of colors, and one of the parts, the yellow part, and what that was it was an instrument that is available worldwide on trying to understand what your learning style is, and what I'd like to do is just get your view on whether you think its correctly assessed what your learning style is? It has got 4 dimensions and I'd just like to go through that with you. The first dimension is active or reflective, a person who is reflective likes to think about things, whereas a person who is active likes to do it and the reflective person likes to work alone and an active person likes to work in groups. It saying that you are fairly reflective, do you think that's correct?

Lindiwe It is, because I don't really like studying in groups, unless its like after, maybe like two days before a test or exam and we ask each other questions, but generally I can't study in a group.

Linda Okay, so you think that this is correct. And then the next one is sensing or intuitive, a person who is sensing likes to learn the facts you like detail, a person who is intuitive likes concepts and relationships a person who is sensing doesn't like surprises in exams yeah

Lindiwe I [xxxx] I like sensing, I like [xxx], I don't like surprises in exams.

Linda So you agree with that? And then the other one is visual or verbal, verbal means that you like words, whether its written words or heard words, a lecture or books whereas visual says you like pictures, diagrams, graphs, would you, it says that you are quite strongly visual

Lindiwe Yes I prefer, because those tend to stick

Linda You say pictures?

Lindiwe Yes I tend to normally [xxxx] I tend to forget words. I'll end up doing something totally [xxxx] I actually learn with pictures.

Linda Okay, thank you. And the last one is called sequential or global, a sequential person likes to learn things step by step, whereas a global person tends to get the whole picture first, you are quite finely balanced between the two but it says you are slightly more sequential, do you have any remarks? do you think that's the correct?

Lindiwe I think it I correct, for me to understand the whole, lets say for example to understand a whole concept, I've got to really go thorough it step by step. Otherwise if I try and just understand it and not go step by step I end up not fully understanding it. And if they say, if a question is written in a way I did not expect, I would not be able to answer the question.

Linda Okay, thank you. Lindiwe, the last thing I'd like to chat with you, the second last thing is about how you study FAC?

Linda Okay, Oh sorry ,before we move onto there, what I have got is, this is some notes on this instrument on learning styles, if you'd like to have a look at it, you're welcome to have it, it does emphasize what's more important is what you think your learning style is. It will just give you some background on it and tell you a little bit about it if you are interested..

Question 5

Linda Okay, how do you go about studying FAC and why do you study it that way?

Lindiwe Okay well FAC. I think – how do I explain? okay I read the notes that Ian gives us, and from there, I go to a library and try to find the books, and then try and understand more about the topic and try and find more examples than has been given to me, [xxxxxxxxxx] more examples, [xxx] usually I refer to my maths text books, because FAC is basically maths.

Linda Okay, so if you had an exam tomorrow, how would you go about studying for that in FAC?

Lindiwe There is not a lot of theory in it, so I would really just try and brush up on my [xxxx] and on my maths, my mathematical reasoning

Linda And how would you go about brushing up on mathematical reasoning?

Lindiwe I would go over [xxxx] (then in a strong voice), okay, I will go to a library, try and find books which I hadn't used before, and look at the example and try and do them and the extra questions in the book I would try and do them, and (hesitates) probably call a friend, and ask them if they can do (voice goes softer) [xxxxxxx] then a question, and ask them if they can do it, and then arrive at the same answer as me I know I'm on the right track, I wouldn't be able to consult.

Linda Okay, and if you were practicing just, okay that's if you have an exam tomorrow so you can't consult. How do you study it on a normal week, how do you study FAC?

Lindiwe Okay, during the tuts I try and ask my tutor to help me with the areas I [xxxxx] and if I still don't understand the notes then [xxxxxxx] I go to Ian

Linda Okay, thank you. What I want to do is have a look at the second example, you've given me an idea of how you study generally, you know, one of your Lecturers told you that one of the exam questions is going to be on inductive proofs, so what are you doing, or how you're going to prepare, you know about inductive proofs, proofs by induction, how are you, or how will you prepare for the exam question on inductive proofs?

Lindiwe I'm going to have to go through it again, because I don't, I've forgotten how to do the inductions and sigma notation, so because apparently, okay Paul said it was the short-hand method to do mathematical induction, so I will go through that and also

Linda When you say you're going to go through it, how are you going to go through it?

Lindiwe Okay, I'm going to, I'm going to have to find a text book and read about the, about mathematical induction, and then go through it step by step to see how its actually done, and then from there, hopefully I will understand, and then I've got to go through some examples on inequality yeah, proving inequalities, and the factorial.

Linda When you say you've got to go through some examples, can you explain to me or give me an example of how you go through some examples?

Lindiwe Okay, it will usually [xxxxx] what is in the textbook, so I just read, and then step by step I try and reason why they did that step until I get to the answer.

Linda Thank you, and then in your work you've also got graph theory and you've got algorithms. You study graph theory and you study algorithms, in your course notes, can you tell me how you would study them differently? Are they the same or how would you study a question on algorithms how would you study a question on graph theory? *(I did not ask this question very well.)*

Lindiwe Well the question on graph theory, okay most of the questions that I [xxx]

Linda Okay, how do you study graph theory, how do you study algorithms? Maybe that's an easier way to put it. *(Question rephrased better.)*

Lindiwe Okay, graph theory, there is a lot of theory in it, so, I'm just trying to understand the theory behind it.

Linda What do you mean by understand the theory?

Lindiwe Okay, I tend to sort of like try it, to … , lets say for example, (pause), okay lets say um, I really want to grasp what I am studying, I'll [xxx] in graph theory there is binary search trees, and then there's a root and then there are siblings, descendants, so I can like, lets say try, lets say write some names of people that I know, okay lets say for example, take my family as an example, [xxxxx] this person is the ruler of the family and these are siblings, and this is, okay, this [xxxx] and that is an ancestor.

So I can really understand it, because I don't like to just read it and cram because if I do that if I miss one word then I won't be able to have [xxxxx], and then with algorithms, okay a friend of mine told me that I should also reason behind why an algorithm is written in that way, so during the steps of algorithm I tend to choose [xxxxx xxxxx]

Linda Okay, very good. Do you think there's a different way of studying graph theory and algorithms then?

Lindiwe No

Linda No. Okay.

Question 6

Linda What I'd like to do now is just go through your questionnaire a bit and just get a better understanding, from what you wrote on it. I notice that you said that you don't feel you're doing so well

Lindiwe No

Linda In the course. And why do you think that is Lindiwe?

Lindiwe Most of the time, okay the first test, I [xxx] understand some of the stuff like the proofs, but then I studied them, and then the second test, I knew the stuff but then its just that I spent so much time trying to answer, trying not to [xxxx] that I actually ran out of time and, I guess that I'm a bit slow, so I run out of time.

Linda What do you think you can do differently to do better?

Lindiwe I'm going to have to write faster.

Linda Okay

Lindiwe Because during the last test, when we spent time out and the third question [xxxx] I was like [sigh] I could easily have done this, so I just need to work faster

Linda Okay. Do you think the FAC course can be changed to help you do better?

Lindiwe They could, give us more examples because they don't really give us that many examples, give us more examples and

Linda How do you think, sorry, and?

Lindiwe And also solutions, solutions to the [xxx] and to exercises. They don't give us solutions, but Ian says he doesn't like giving us solutions, because he wants us to go to him if we got problems, but I understand that, but at the time when you come for consultation there's a, because you [xxxx]

Linda Okay, thank you. Its been very useful.

Question 7

Linda Thank you for your time, really I appreciate it, specially with your exams so close, what I'm going to plan to do is I'm going to try and write down what we talked about, and if I can get hold of you, try and ask you if you'd mind

		just having a look and make sure that you're happy with what I've written down?
	Lindiwe	Okay
	Linda	Okay? Thank you very much, and all the best as you prepare for your exams.
	Lindiwe	Thank you
	Linda	That's just for interest. I'm just going to turn this off, is that okay?
	Lindiwe	Yeah.
	End of interview	

ANALYSED INTERVIEW **APPENDIX J**

INTERVIEWER: Linda Wedderburn

INTERVIEWEE: James (pseudonym)

Categories: **Green – background**
Yellow – Learning Approach
Blue – Learning style
Pink – Student "advice" re FAC
Grey – Understanding of what CS about and what they want to do when completed varsity
Brown – Other emergent themes

As this is the last interview transcribed, I have both classified the particular responses from James as well as made some comments on all the responses where relevant to assist in the synthesis of the responses across interviews.

Question 1

Linda First of all, thank you James for your time.

(introductions)

Linda Its very noisy out there?

James They're pushing a fridge

Question 2

James Okay

James Yes (to use tape recorder)

James No questions

Question 3

Linda What I'd like to do to start with, is just check the information I have on you from the questionnaire okay? You're 19, your home language is Siswati.

James Yes

Linda You're from Nelspruit

James Yeah

Linda And your mom or dad is a messenger Dad is a messenger

James Its my dad

Linda Your dad okay. You went to a Government school?

James Yes

Linda You got 74% for maths?

James Yes

Linda Is that higher or standard grade?

James Higher grade good mark for Maths HG

Linda Very good so you got a very high mark?

James Yes

Linda Must have worked hard at school to get that?

James Yes

Linda What courses are you studying this year James?

James Okay, its Computer Science, Chemistry, Maths and Physics
Very different to most of the others

Linda Okay. A very Science degree. And which course do you like the most?

James Its Computer Science

Linda And why do you like that the most?

James My interest are in Computers, that's why I chose Computer Science this year, the other ones are just for the first year BSc degree / course

Linda Okay, and why are you interested in computers James?

James Whew, most of the blacks are taking Computer skills, so, just to get the initiative to [xxxxx] Unfortunately cannot hear James' reply. Sounds like he does not want to learn just computer skills, but more than this.

Linda Okay, and what do you want to do with Computers once you've completed your degree?

James Design my programs Interest in programming.

Linda You want to design programs?

James Yeah.

Linda And anything else, or is that?

James No, just to work with computers. Does not appear to know what would be included in the Computer Science curriculum and does not realize that computers (computer science) is more than programming.

Linda And are you studying in Computer Science what you thought you would?

James Yes

Linda Yes?

James Yeah

Linda What did you think you would be studying when you did your Computer Science then?

James Studying programming, and computer languages. James has said that he is studying what he expected to study in CS and he says he expected to study programming and computer languages, but CS I has little of programming and computer languages.

Linda Okay, which course do you like the least James?

James Its Chemistry

Linda And why do you like that the least?

James No Chemistry, just takes a lot of time and I'm doing other subjects so don't have, most of your time doing Chemistry

Linda Okay, so you don't have time to do it?

James Yeah

Question 4

Linda Okay, then what I'm trying to do is part of the questionnaire that you answered okay, there was a yellow part to it, and that was trying to work out is what is your learning style, and what your learning style is, how you go about learning, there's no right or wrong way to it its just how you do it. And what I'd like to get an understanding from you is whether you agree with it because not everybody would necessarily agree with how it is okay? It has four dimensions one is active and one is reflective, an active person likes to do things okay, likes to work in groups whereas a reflective person likes to think about it likes to work on their own, it says here that you're fairly active, would you agree with that or?

James Yeah I agree.

Linda Any comments on it

James No, its just that maybe if I [xxxx] the first two tests of FAC, I passed one with 50% the other one I failed, because I was studying alone, then the third one for sure I hope I passed because I was doing it in the group so I've learned many things there. Likes group work – active learner

Linda Okay, that's interesting thank you. Then the next thing is sensing or intuitive. Okay, where a person is intuitive likes to learn concepts, relationships likes to see how this course relates to other courses a person who's sensing likes to learn the facts likes a lot of detail attention to detail, it says that you're very well balanced on the two but you're probably slightly more intuitive than sensing, would you agree with that or not?

James I would agree

Linda Any comments on that?

James Wheww, Because no I like reading books and maybe get the concept from it, then before I can put it into practice. Does not validate an intuitive style.

Linda Okay. And then the other one is visual and verbal. A verbal person likes to get words, either through reading or listening to lectures, whereas visual is you like pictures, you like diagrams, graphs it says you're quite strongly visual

James Yeah I agree also, cause when I was in matric I got the [xxxx] who told me that if you want to understand your work then you must use both parts of your brain and so on, that's why I like seeing pictures, drawing mind-maps and just get it from pictures. Confirms a visual learning style.

Linda Very good. And then the last one is what they call sequential or global. The person who is sequential likes to learn things step by step whereas a person who's global learns it in bits and pieces and understands the whole picture first, it says that you're fairly sequential would you agree with that?

James Yeah I agree

Linda Do you?

James Yeah

Linda Any comments on that?

James Cause no, when I'm studying, I start with a piece which I understand first and then go on go on go on, maybe step only [xxxxx] Confirms a sequential learning style

Linda Okay, thank you very much.

Question 5

Linda Then the next bit I'd like to get your views on, is I'd like to understand how you go about, oh first of all, before I go on to this, for your interest if you would like it I've got a copy about this on learning styles it shows where you are on the learning styles and it just tells you a little bit about it and you can take it with you, you can use it throw it away its just for interest to say thank you for your time okay?

James Yeah

Linda Okay, coming back to learning approaches, you know how you go about learning, can you explain to me, how you study and learn the FAC course and why you do it that way?

James I check my notes, then I see which [xxxx] I already [xxx] first time, then I will study it, then I ask myself questions about [xxxx] aspect question from that part, then answer, then if it needs a little bit of practice, then get some equations to practice, then I will just practice. James notes that he first studies the material, then asks himself questions, and then he gets equations to

practice. This is generally an appropriate approach for FAC – an appropriate deep learning approach.

Linda And how do you practice?

James Like say, give me another question which I would like to do, then do it from now on, and then check whether its correct. Practices – characteristic of a deep learning approach.

Linda Okay, and how do you check if its correct or not?

James whew, I'll check by contacting my friend an active learning style
It seems that there are limited ways for students to check if their solutions are correct
The FAC lecturer does encourage students to hand in material for marking, but few, if any students, did this

Linda Okay

James Yeah, I'll be checking books maybe its got solutions Using books could be characteristic of a deep approach.
But also get the impression that students are seeking example solutions. I do not get the impression that students are wanting to be told what to do and told what is the right answer, but they are wanting to see if their answers are correct and if they are tackling the work the correct way. There is little point on practicing if you are doing it the wrong way all the time and do not realize this. I get the impression that scaffolding is required

Linda Okay. So if you had an exam tomorrow, on FAC what would you do today?

James To be for sure, I would finish studying my notes, then I would just checking question papers, past papers A sound general approach in FAC: first do the studying – could be "rote learning" and then do the examples – characteristic of a deep approach.

Linda Okay. Let's take a typical example, I believe your Lecturer has told you that there'll be a question on inductive proofs in the exam, you know what I mean by inductive proofs do you?

James Yeah

Linda Okay. How do you, or will you prepare for an exam question on inductive proofs, particularly inductive proofs

James Yes I will prepare questions

Linda How will you prepare for that question?

James First I know induction is also on maths, so I will just look for papers and text book from that course, cause in Comp Sci there are not too many on induction, so I'll do them and understand the concept of induction and practice many equations on induction. First understands the concepts and then practices examples – a sound deep approach for FAC.
Uses appropriate books and evident has tried to find CS books on induction, but finds it more readily in maths – deep approach.
Integrates his learning across courses – characteristic of a comprehension learning approach – a deep approach.

Linda And when you practice can you explain to me, or give me an example on how you actually practice, what do you do?

James Whew, I just write the question, okay, then close that page, then do it, or I'll try to get there, if I get wrong, then I go back and check where I did wrong.
Does not just read examples, but tries to do the example by himself, then checks the answer and revisits if a mistake. This is indicative of a deep approach for the FAC course.
However, James does not appear to have abstracted out the process which should be applied to all inductive proofs – an operational learning approach.
There is also no evidencd of James having tried novel questions, that is questions that have not been done in class or laboratory sessions.

Linda Okay, thank you. And then, lets move on to graph theory or algorithms, how would you study a question on graph theory or how do you study graph theory compared to how you study algorithms, do you know what I mean by graph theory and algorithms?

James Yeah I know

Linda How would you study for graph theory, how would you study for algorithms?

James Graph theory, there is a bit of theorems and then you need to apply those theorems. So I'll just first study it from the manuals, study theorems, know what does this mean, then just check for past papers, try to answer the question using the theorems I learnt from my book. Emphasises that first learns the theorems. James follows the correct approach – first learns the material and definitions and then does examples. – Deep approach.

Linda Okay. And algorithms?

James Everything's [xxx] particularly bad. When I'm studying, I'll first study my notes, then try to get some other equations which I can get from Computer Science books, try to analyze them and check the order first and then practice on, try to practice as many as I can Not sure if first phrase transcribed correctly as not clear on the tape.
Uses books, (computer science), deep approach.
Analyses – deep approach
Practices – deep approach.

Linda Okay. And how do you find, you practice them, what do you say you close your books and do them, what do you do if you don't know the, if it doesn't work for you, what do you do then?

James Then I'll go first I'll ask my friend, then if [xxxx] then I'll go to my Lecturer Asking a friend, tutor or lecturer could indicate a deep approach as James wants to understand the material, or it could indicate a surface approach as James wants to be told the solutions instead of trying to work them out. In this instance I believe it is showing a deep approach as James had spent time trying to work out the solution and is interested enough in the subject to approach a friend, lecturer or tutor .

Linda Okay. Have you gone to your Lecturer at all

James I ask my tutor? The lecturer says he is available to assist students, but none of the students interviewed have approached the lecturer, the tutors are approached for assistance .

Linda Your tutor.

James Yes

Linda Thank you.

Question 6

Linda What I'd like to do is while we just look at the questionnaire that you answered with you okay? And just get a better understanding of some of the things from the questionnaire. You said, one of the questions was . [Question 2 of Learning Approaches] "I like to be told precisely what to do in the FAC tut/lab sessions", and you said none of the above expresses your view. Can you give me an understanding of, do you like to be told precisely what to do, or do you agree or disagree with that statement, and why?

James Okay I'd like to, yes I agree

Linda And why?

James Because I will know what to do then, how to learn, and how to [xxxx} Indicative of a surface approach.

Linda Okay, thank you, so that was question 2. And then on question 4, you said you often find yourself questioning things, or the question is, "I often find myself questioning things I hear in class or read in books", do you agree or disagree with that statement?

James I agree

Linda And the reason?

James Because if you want to understand something better, then you have to ask questions, so I see it like this, before I can understand. Wanting to understand is indicative of a deep approach

Linda Okay

James Yeah

Linda Okay, I understand, that makes a lot of sense. And then, the last question, section C was, how well do you think you're doing, and you say you don't think you're doing so well, that you're a 3, and you think you could do better, because you know that you're capable of doing better. Why do you think you're not doing as well as you could James?

James Sure because I failed the [xxxxx] test.

Linda And why do you think you failed?

James The reason because I was studying on my own, I was not using the [xxxx] resources I've had to use An active learning style – likes to work in groups. But, over simplifying the reason for failure – insufficient meta-cognition .

Linda Okay, so you think you can do better by studying with other people. Do you think there's anything that the FAC course could do to make it easier for you, or to make it, for you to do better?

James I think there is

Linda And what do you think that is?

James Maybe if we can organize more tuts on computer, not one per week, and maybe to just add time for us to ask questions on an issue [xxxx] for FAC

Require more tuts and time to ask questions – could indicate more scaffolding is required.

Linda Okay.

James Yeah

Linda Thank you very much.

Question 7

Linda Thanks for your honesty, for your openness, is there anything else that you would like to add?

James Just that I want to wish you luck on your research

Linda That's very kind of you.

James Yeah

Linda I want to thank you for your time, especially with the exams so close, I do appreciate it, thank you for being so prompt as well. Just to say, what I'm planning to do is I'm planning to write what we've talked about and if I can get hold of you, and you've got time, I'd like to ask you if you'd mind just reading it and see if it's a correct reflection of what we talked about?

James Yeah

Linda Is that okay?

James Yes

Linda Thank you very much.

End of interview.

REFERENCES

Baldwin, D. (1990). Teaching Introductory Computer Science as the Science of Algorithms. *ACM Special Interest Group on Computer Science Education (SIGCSE) Bulletin.*vol.22, no.1, pp.58-62.

Bell, J. (1993). *Doing your research project: a guide for first-time researchers in education and social science.* Second Edition. Buckingham : Open University press.

Bennett, J., Rollnick, M., Green, G. and White, M. (2001). The development and use of an instrument to assess students' attitude to the study of chemistry. *International Journal of Science Education,* vol.23, no.8, pp.833-845.

Biggs, J. (1987). *Student approaches to learning and studying.* Melbourne: Australian Council for Educational Research.

Biggs, J. (1988). Approaches to learning and to essay writing. In Schmeck, R.R. (Ed). *Learning Strategies and Learning Styles*. New York: Plenum Press. pp.185-228.

Booth, S. (1992). *Learning to program: A phenomenographic perspective.* Gothenburg, Sweden: Acta Universitatis Gothoburgensis. Chapter 3 (The phenomenographic research tradition) and Chapter 7 (Approaches to writing programs).

Bosa-Barlow, A. (1999). *The design and development of CAI materials to teach the topic "Plant mineral nutrition" to Botany 1 students at UNITRA.* PhD thesis, University of the Transkei, Umtata.

Bowden, J. and Marton, F. (1998). *The University of Learning.* London: Kogan Page.

Byrne, M., Catrambone, R. and Stasko, J. (1999). Evaluating animations as student aids in learning computer algorithms. *Computers and Education.* vol.33, pp.253-278.

Case, J. (2004a). Approaches to learning: a critical examination of inventory responses from third year chemical engineering students. *Proceedings of the 12th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education.* Durban. pp.102 - 110. Available at

http://www.phy.uct.ac.za/SAARMSTE2004/proceedings2004/data/index.html. Last accessed 8 February 2004.

Case, J. (2004b). An alternative view on student learning: alienation and engagement in the chemical engineering student experience. *Paper presented at the Process Engineering Educators' Conference* at the University of the Witwatersrand, Johannesburg, July 2004.

Case, J. and Gunstone, R. (2002). Metacognitive development as a shift in approach to learning: an in-depth study. *Studies in Higher Education*, vol.27, no.4, pp.460–470.

Case, J., Gunstone, R. and Lewis, A. (2001). Students' metacognitive development in an innovative second year chemical engineering course. *Research in Science Education.* vol.31, pp.313-335.

Chamillard, A.T. and Karolick, D. (1999). Using learning style data in an introductory computer science course. *Proceedings of the* 30th *Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium.* New Orleans, Louisiana USA. March 1999. pp.291–295.

Chen, P. (2003) *Persistence, personality type and learning style of computer science students.* Honours Research Report, University of the Witwatersrand, South Africa.

Claxton, C. and Murrell, P. (1987). Learning Styles: Implications for Improving Educational Practices. *ASHE-ERIC Higher Education Report No. 4*. Washington, D.C.: Association for the Study of Higher Education.

Cohen, L. and Manion, L. (1980). *Research methods in education.* London: Helm.

Denning, P.J., Comer, D.E., Gries, D., Mulder, M.C., Tucker, A., Turner, A.J. and Young, P.R. (1988). Computing as a discipline: Final report of the ACM Task Force on the Core of Computer Science. *Communications of the ACM.* vol.32, no.1, pp.9-23.

Denzin, N.K. and Lincoln, Y.S. (1998). *Collecting and Interpreting Qualitative Materials.* London: Sage Pubications.

Entwistle, N.J. (1988). Motivational factors in students' approaches to learning. In Schmeck, R.R. (Ed). *Learning Strategies and Learning Styles*. New York: Plenum Press. pp.21–52.

Entwistle, N.J. (2004). "Phenomenography – Noel Entwistle" available at http://facultyweb.cortland.edu/andersmd/learnings/Phenomenography.htm. Last accessed 28 March 2004.

Entwistle, N.J. and Ramsden, P. (1983). *Understanding student learning*. Kent: Croom Helm Ltd.

Felder, R.M. (1992). There's nothing wrong with the raw material. *Chemical Engineering Education*. vol.26, no.2, pp.76-77. Available at http://www.ncsu.edu/felder-public/Columns/Rawmaterial.htm. Last accessed 17 March 2004.

Felder, R.M. (1993). Reaching the second tier: learning and teaching styles in college science education. *Journal of College Science Teaching*, vol.23, no.5, pp.286-290. Available at *http://www.ncsu.edu/felder-public/Papers/Secondtier.htm.* Last accessed 7 February 2004.

Felder, R.M. (1995). Learning and teaching styles in foreign and second language education. *Foreign Language Annals*, vol.28, no.1, pp.21–31. Available at *http://www.ncsu.edu/felder-public/Papers/FLAnnals.pdf*. Last accessed 7 February 2004.

Felder, R.M. (1996). Matters of Style. *American Society for Engineering Education (ASEE) Prism.* vol.6, no.4. pp.18-23. Available at http://www.ncsu.edu/felder-public/Papers/LS-Prism.htm. Last accessed 7 February 2004.

Felder, R.M. (June 2002). Author's preface to "Learning & teaching styles in engineering education". Available at *http://www.ncsu.edu/felder-public/Papers*. Last accessed 7 February 2004.

Felder, R.M. (2004a). Learning styles. Available at *http://www.ncsu.edu/felder-public/Learning_Styles.html*. Last accessed 17 January 2004

Felder, R.M. (2004b). Richard Felder's responses to frequently asked questions about the ILS. Available at *http://www.ncsu.edu/felder-public/ILSdir/ILS-faq.htm*. Last accessed 17 January 2004.

Felder, R.M. and Brent, R. (2005). Understanding student differences. *Journal of Engineering Education.* vol.94, no.1, pp.57-72. Available at http://www.ncsu.edu/felder-public/Papers/Understanding_Differences.pdf. Last accessed 17 March 2005.

Felder, R.M. and Silverman, L.K. (1988). Learning and teaching styles in engineering education. *Engineering Education.* vol.78, no.7, pp.674-681. Available at *http://www.ncsu.edu/felder-public/Papers/LS-1988.pdf*. Last accessed 7 February 2004.

Felder, R.M. and Soloman, B. (2004a). Index of Learning Styles. Available at *http://www.ncsu.edu/felder-public/ILSpage.html*. Last accessed 17 January 2004.

Felder, R.M. and Soloman, B. (2004b). Learning Styles & Strategies. Available at *http://www.ncsu.edu/felder-public/ILSdir/styles.htm*. Last accessed 17 January 2004.

Felder, R.M. and Spurlin, J. (2005). Applications, reliability, and validity of the Index of Learning Styles. *International Journal of Engineering Education.* vol.21, no.1, pp.103-112.

Feyock, S. and Ford, T. (1976). Individual learning styles and computer science education. *Proceedings of the Annual ACM Conference.*

Finnie, G.R. (1987). On learning styles and novice computer use. *Quaestiones Informaticae*, vol.5, no.1, pp.1-10.

Flavell, J. (1981). Cognitive Monitoring. In Dickson, W. *Children's Oral Communication Skills*. Academic Press.

Fraenkel, J. and Wallen, N. (1990). *How to design and evaluate research in education.* New York: McGraw-Hill Publishing Company. Chapter 16 (Qualitative Research). pp367-407.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The Qualitative Report.* vol.8, no.4, pp.597-607. Available at http://www.nova.edu/ssss/QR/QR8-4/golafshani.pdf. Last accessed 14 January 2005.

Gregorc, A.F. (2004 a). Gregorc Associates: frequently asked questions. Available at *http://www.gregorc.com/faq.html*. Last accessed 25 January 2004.

Gregorc, A.F. (2004 b). Gregorc Associates Inc. Instrument: Gregorc Style Delineator. Available at http://www.gregorc.com/instrume.html. Last accessed 25 January 2004.

Grinder, M.T., Kim, S.B., Lutey, L.L., Ross, R.J. and Walsh, K.F. (2002). Loving to learn theory – active learning modules for the theory of computing. *Proceedings of the 33rd Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium.* Northern Kentucky, USA, 27 February– 3 March 2002. pp.371-375

Haggis, T. (2003). Constructing images of ourselves: a critical investigation into "approaches to learning" research into higher education. *British Educational Research Journal.* vol.29, no.1, pp.89–104.

Hartmanis, J. (1995). Turing award lecture on the computational complexity and the nature of computer science. Symposium on Computational Complexity and the Nature of Computer Science, *ACM Computing Surveys.* vol.27, no.1, pp.7-15.

Hill, J., Ray, C., Blair, J. and Carver, C. (2003). Puzzles and games: Addressing different learning styles in teaching operating systems concepts. *Proceedings of the 34th Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium.* 19 - 23 February 2003. Nevada, United States. pp.182-186.

Honey, P. and Mumford, A. (1982). *The Manual of Learning Styles.* Maidenhead Berkshire: Peter Honey.

Howard, R.A., Carver, C.A., and Lane, W.D. (1996). Felder's learning styles, Bloom's taxonomy and the Kolb learning cycle: tying it all together in the CS2 course. *Proceedings of the 27th Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium.* March 1996. Philadelphia, PA, United States. pp.227-231.

Hubscher-Younger, T. and Narayanan, N.H. (2003) Constructive and collaborative learning of algorithms. *Proceedings of the 34th Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium*. 19–23 February 2003. Reno, Nevada, USA. pp.6–10.

Jagielski, R. (1988). Visual simulation of finite state machines. *ACM Special Interest Group on Computer Science Education (SIGCSE) Bulletin.* vol.20, no.4, pp.38-40.

Kann, C., Lindeman, R. and Heller, R. (1997). Integrating algorithm animation into a learning environment. *Computers and Education.* vol.28, no.4, pp.223-228.

Kolb, D.A. (1984). *Experiential Learning: Experience as the Source of Learning and Development.* Prentice-Hall Inc., Englewood Cliffs, New Jersey.

Kolb, D.A. (1985). *Learning style inventory.* Massachusetts: McBer and Company.

Lewandowski, G. and Morehead, A. (1998). Computer Science through the eyes of dead monkeys: learning styles and interaction in CS1. *Proceedings of the 29th Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium*. 26 February – 01 March 1998. Atlanta, Georgia, United States. pp.312–316.

Lincoln, Y.S. and Guba, E.G. (1985). *Naturalistic Inquiry.* Beverley Hills, California: Sage.

Marshall, D. and Case, J. (2003). Approaches to learning: a useful heuristic framework for higher education or a reified and elitist dichotomy. *South African Academic Development Association (SAADA) Conference.* 3–5 December 2003. Cape Town.

Marton, F. (2004). Theory of Variation and Phenomenography. Available at http://www.cmi.hku.hk/hclam/mite6218/variation.pdf. Last accessed 20 February 2005.

Marton, F. and Säljö, R. (1984). Approaches to learning. In Marton, F. Hounsell, D. and Entwistle, N. *The experience of learning.* Edinburgh: Scottish Academic Press. pp.36-55.

McCune, V and Entwistle, N. (2000). The deep approach to learning: analytic abstraction and idiosyncratic development. *Paper presented at the Innovation in Higher Education*

Conference, 30 August – 2 September 2000, Helsinki, Finland. Available at http://www.ed.ac.uk/etl/docs/mccune2000.pdf. Last accessed 3 May 2004.

McConnell, J. (2001). *Analysis of Algorithms: An Active Learning Approach.* Jones and Bartlett Computer Science.

Mendenhall, W. and Ott, L. (1980). *Understanding Statistics, Third Edition.* Belmont California: Wadsworth, Inc.

Morrow, W. (1994). Entitlement and achievement in education. *Studies in Philosophy and Education.* vol.13, pp.3-47.

Mouton, J. (2001). *How to succeed in your master's and doctoral studies: A South African guide and resource book.* Pretoria: Van Schaik.

Neumann, W.L. (1997). *Social research methods: qualitative and quantitative approaches.* USA: Allyn and Bacon.

Oppenheim, A. (1996). *Questionnaire design and attitude measurement.* London: Heinemann.

Pask, G. (1988). Learning strategies, teaching strategies, and conceptual or learning style. In Schmeck, R.R. (Ed). *Learning Strategies and Learning Styles*. New York: Plenum Press. pp.83-100

Posner, G. and Gertzog, W. (1982) The clinical interview and measurement of conceptual change. *Science Education.* vol.66, no.2, pp.195-209

Powney, J. and Watts, M. (1987). *Interviewing in Educational Research.* London: Butler and Tanner Ltd.

Ramsden, P. (1992). *Learning to teach in higher education.* London and New York: Routledge.

Regan, J. and Regan, L. (1995). Changes in University students' study processes during the first year of their undergraduate courses in relation to age, gender and faculty. *Paper*

presented at the 25th Annual Conference of the Australian Association for Research in Education (Hobart 26-30 November 1995). Available at http://www.aare.edu.au/95pap/regal95.057. Last accessed 28 March 2004.

Richardson, J. (2000). *Researching Student Learning Approaches to Studying in Campus-based and Distance Education*. Buckingham: The Society for Research into Higher Education and Open University Press.

Rollnick, M (2005). Digging for gold: A new look at science access programmes. *Proceedings of the 13th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education.* Windhoek.

Rollnick, M., Bapoo, A., Davidowitz, B., Keane, M. and Magadla, L. (2004). Who will pass your course? – towards developing study approaches profiles for access students in science. *Proceedings of the 12th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education*. Durban. pp.880-887. Available at http://www.phy.uct.ac.za/SAARMSTE2004/proceedings2004/data/index.html. Last accessed 8 February 2004.

Rollnick, M., Bapoo, A., Davidowitz, B., Keane, M. and Magadla, L. (unpublished paper). Developing study approaches for current and future science students – what is a passing profile?

Sanders, I.D. (2004). COMS100C, Fundamental Algorithmic Concepts course notes. School of Computer Science, University of the Witwatersrand, Johannesburg, South Africa. First Semester, 2004 Academic Year.

Sanders, I.D. and Mueller, C.S.M. (2000). A fundamentals-based first year computer science curriculum. *Proceedings of the 31st Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium*. Austin, Texas, USA, 8-12 March 2000. pp.227-231.

Sanders, M. (1995). A useful format for questionnaires and tests used in educational research. In Hendricks,A. (1995). *Volume 1 of the Proceedings of the Third Annual*

Meeting of the Southern African Association for Research in Mathematics and Science Education. 25-29 January. pp.712-725.

Sayed, Y. (1988) *Investigating the Learning Styles of First Year Students using Honey & Mumford's Learning Styles Questionnaire.* Research Report submitted to the Faculty of Education University of the Witwatersrand, Johannesburg in partial fulfilment of the requirements for the degree of Master of Education.

Schmeck, R. (1988). An introduction to strategies and styles of learning. In Schmeck, R.R. (Ed). *Learning Strategies and Learning Styles*. New York: Plenum Press. pp.3-19.

Schumacher, S. and McMillan, J. (1993). *Research in education (3rd Ed.)* New York: McGraw-Hill Publishing Company.

Tesch, R. (1990). *Qualitative research: Analysis Types and Software Tools.* Hampshire, UK: Falmer Press.

Thomas, L., Ratcliffe M., Woodbury, J., Jarman, E. (2002) Learning styles and performance in the introductory programming sequence. *Proceedings of the 33rd Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium*. 27 February – 3 March 2002. Northern Kentucky, United States. pp.33-37

Thompson, P (1978) *The voice of the past.* Oxford: Oxford University Press. Chapter 7. The interview.

Treisman, U. (1992). Studying students studying calculus: A look at the lives of minority mathematics students in college. *College Mathematics Journal.* vol.23, no.5, pp.362-372.

Turmo, A. (2004). Scientific literacy and learning strategies – empirical results from the PISA study. *Proceedings of the International Organisation for Science and Technology Education (IOSTE): XIth Symposium.* 25-30 July 2004. Conference proceedings on CD. Abstract pp.229-230. Lublin, Poland.

University of Edinburgh (2004). ASSIST: Approaches and study skills inventory for students. Available at http://www.ed.ac.uk/etl/questionnaires/ASSIST.pdf. Last accessed 28 March 2004.

Van Zwanenberg, N., Wilkinson, L.J., & Anderson, A. (2000), Felder and Silverman's Index of learning Styles and Honey and Mumford's Learning Style Questionnaire: How do they compare and do they predict academic performance*? Educational Psychology*. vol.20, no.3, pp.365-381.

Viljoen, M.J., Schepers, J.M. and Van Zyl, K. (2001) The construction and evaluation of a normative learning style preference questionnaire. *Journal of Industrial Psychology*, vol.27, no.3, pp.51-60.

Vlaardingerbroek, B. and Ros, L. (1990). Educational transition rates and upper secondary students' arithmetical ability in five developing countries. *Educational Studies in Mathematics.* vol.21, no.5, pp.454-460.

Winter, G. (2000). A comparative discussion of the notion of "validity": in qualitative and quantitative research. *The Qualitative Report.* Vol. 4, no.3 & 4. Available at http://www.nova.edu/ssss/QR/QR4-3/winter.html. Last accessed 14 January 2005.

Wulf, W.A. (1995). Are we scientists or engineers? symposium on computational complexity and the nature of computer science, *ACM Computing Surveys*. Vol.27, no.1, pp.55-57.

Wyman, P. The Power of your personal learning style. Available at http:// *www.howtolearn.com/personal.html*. Last accessed 25 January 2004

Yahya, A.H. (1992). Local considerations in computer science curricula development. *ACM Special Interest Group on Computer Science Education (SIGCSE) Bulletin*. vol.24, no.1, pp.123-128.

Zywno, M.S. (2003). A contribution to validation of score meaning for Felder-Soloman's Index of Learning Styles. *Proceedings of the 2003 American Society for Engineering Education Annual Conference and Exposition, American Society for Engineering Education.* Available at *http://www.ncsu.edu/felder-public/ILSdir/Zywno_Validation_Study.pdf*. Last accessed 17 March 2004.

BIBLIOGRAPHY

Bland,C. and Lawhead,P. (2000). Agents, profiles, learnimng styles and tutors. A poster from the *Proceedings of the 5th annual SIGCSE / SIGCUE ITiCSE conference on Innovation and technology in Computer Science Education.* vol.32, no.3.

Boughey, C. (2003). "Epistemological" access to the university: an alternative perspective. *Paper Presented at SAADA conference*, Cape Technikon.

Byrne, G. and Lyons, P. (2001). The effect of student attributes on success in programming. *Proceedings of the 6th annual conference on Innovation and technology in computer science education*. pp.49-52. Canterbury, United Kingdom.

Dey, S. and Mand, L.R. (1986). Effects of mathematics preparation and prior language exposure on perceived performance in introductory computer science courses. *Proceedings of the 17th Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium.* Cincinnati, Ohio, USA, 21-25 February 1986. pp.144–148.

Dunn,R. and Dunn, K. (1978). *Teaching Students through their individual learning styles: a practical approach.* Virginia: Reston Publishing Company, Inc.

Felder, R.M. and Brent, R. Active and cooperative learning. Available at http://courses.durhamtech.edu/tcl/www/html/Resources/Felder.htm. Last accessed 13 January 2005.

Goold, A. and Rimmer, R. (2002). Factors affecting performance in first-year computing. *ACM Special Interest Group on Computer Science Education (SIGCSE) Bulletin*. vol.32, no.2, pp.39-43.

Hendrick, U. (2001). *The power of locus of control and learning strategies as predictors of academic success*. MEd dissertation. University of the Witwatersrand, Johannesburg.

Jenkins, T. (2001) The Motivation of Students of programming. *Proceedings of the 6th Annual conference on Innovation and Technology in Computer Science education*. pp.53–56 Canterbury, United Kingdom.

Long, T.J., Weide, B.W., Hollingsworth, J., Sitaraman, M. and Edwards, S. (2000). Providing intellectual focus to CS1/CS2. *Proceedings of the 31st Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium.* Austin, Texas, USA. 8 – 12 March 2000. pp.252–256.

Morrison, M. and Newman, T.S. (2001) A study of the impact of student background and preparedness on outcomes in CS1. *Proceedings of the 32nd Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium.* Charlotte, North Carolina, USA, 21 – 25 February 2001. pp.179-183.

Norton, L. (2004). Encouraging students to take a deep approach to learning. Available at http://ltsnpsy.york.ac.uk/LTSNPsych/Specialist/Norton/introduction.htm. Last accessed 28 March 2004.

Palakal, M.J., Myers, F.W., Boyd, C.L. (2000). An interactive learning environment for breadth-first computing science curriculum. *Proceedings of the 31st Special Interest Group on Computer Science Education (SIGCSE),* Austin, Texas, USA. 8 – 12 March 2000. pp.1–5.

Ramsden, P. (1984). The context of learning. In Marton, F. Hounsell, D. Entwistle, N. *The experience of learning.* Edinburgh: Scottish Academic Press. pp.144-164.

Ramsden, P. (2004). The transition in the first year. *Available at http://www.usyd.edu.au/su/ctl/Synergy/Synergy12/pramsden.htm*. Last accessed 25 January 2004.

Sidbury, J.R. (1986). A statistical analysis of the effect of discrete mathematics on the performance of computer science majors in beginning computer classes. *Proceedings of the 17th Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium.* Cincinnati, Ohio, USA. 21-25 February 1986. pp.138-143.

Strohm Kitchener, K. (1983). Cognition, metacognition, and epistemic cognition. *Human Development.* vol.26, pp.222–232.

Watson, A. and Martinson, B. (2004) The Influence of Learning Style on the Academic Success and retention of Design Students. *Proceedings of the Hawaii International*

Conference on Education, Honolulu, Hawaii, January 2004. Available at http://www.hiceducation.org/index.htm. Last accessed 8 February 2004

Werth, L.H. (1986). Predicting student performance in a beginning computer science class. *Proceedings of the 17th Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium.* Cincinnati, Ohio, USA. 21-25 February 1986. pp.138-143.

Wilson, C.D. and Shrock, S. (2001). Contributing to success in an introductory computer science course: A study of twelve factors. *Proceedings of the 32nd Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium.* Charlotte, North Carolina, USA, 21-25 February 2001. pp.84-188.

Wolcott, H.F. (1988). Ethnographic research in Education. In Jaeger, R.M. *Complementary Methods for Research in Education*. Washington, DC: American Educational Research Association. Pp.185-300.