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ON THE LEARNING PRACTICES OF FIRST YEAR CHEMICAL AND METALLURGICAL ENGINEERING STUDENTS AT WITS: A PHENOMENOGRAPHIC STUDY

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Thesis presented for the degree of Doctor of Philosophy

University of the Witwatersrand, Johannesburg

APRIL 2013

STATEMENT OF AUTHORSHIP

Except where indicated otherwise, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis by which I have qualified for or been awarded another degree or diploma. No other person's work has been used without due acknowledgment in the main text of the thesis. The thesis has not been submitted for the award of any degree or diploma in any other tertiary institution.

Signed:



Date: 5th November, 2012

GENDER SENSITIVITY

In this thesis the issue of gender sensitivity is handled as follows. Rather than using the somewhat awkward formats of he/she, or s/he, or his/hers etc., or of preferring she over he, the 'singular plural' is used wherever possible – they or theirs is used instead of s/he, his/hers etc. This means that in those instances where she or he or equivalents are used, it indicates the actual gender of the person referred to.

ACKNOWLEDGEMENTS AND DEDICATION

I acknowledge with gratitude the insight, input, patience and kind support
of my supervisors Prof Shirley Booth and Dr Ann Cameron.

I dedicate this thesis to my wife Heather
who has been particularly longsuffering during its preparation.

ABSTRACT

The study presented in this thesis was motivated by the poor academic performance of many entrants to the School of Chemical and Metallurgical Engineering at the University of the Witwatersrand, Johannesburg, South Africa. The premise behind the study is that the learning practices of students – the way they typically go about studying and learning – has a significant bearing on the quality of their learning and consequently on their academic prospects at university. Accordingly, the objective of the study was to develop an evidence-based understanding of the learning practices of our students. The kind of understanding sought was one which could inform interventions and/or curriculum re-design that aim to improve the quality of our students' learning by facilitating an improvement in the quality of their learning practices and, thereby, to reduce attrition. To the extent that our students are representative of entrants to engineering education in the country, the findings of the study could have relevance beyond the context of our school.

The methodology employed to achieve the study's objective was phenomenography. Based on interviews with 31 students from the 2008 entering cohort, qualitatively different types of learning practice were found in 6 different contexts of studying and learning. The variation in the learning practices in four of these contexts was investigated in detail. The practice that was found to exert the most direct influence on the quality of a student's learning was their 'mastering-practice' – i.e. how a student typically relates to and engages with studying and learning when they focus exclusively on the mastering of the requisite knowledge, understanding and skills. Six levels of sophistication in mastering-practice were identified.

Three other types of learning practice were also investigated in depth: learning management practice; class-room practice (how students engage with verbal input of course material); and test-focused study practice (how they typically prepare for tests and exams). The study identified five categories of variation in learning management practice, five categories of variation in classroom practice, and four categories of variation in test-focused study practice. It also found that these practices could influence the quality of a student's learning by the way in which they constrained their mastering-practice or diverted attention away from the exercise of their mastering-practice. The inter-relations between the different types of practice are discussed.

The findings from the phenomenographic studies were augmented by investigations into the dynamics associated with how the students learning practices changed during their first year at university. In addition, the study developed a number of pedagogical tools or procedures for interpreting findings of the kind developed in the study and for using them to guide the design of pedagogical measures for improving students' learning by helping those students to modify their learning practices.

Apart from some theoretical developments that emerged and the specific findings about the nature of the learning practices of our students, the study's contribution to knowledge consists of a methodology for identifying the qualitative essentials of the developmental pathways which students need to negotiate if they are to develop their learning practice to a more sophisticated level.

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PROLOGUE

I am a qualified Metallurgical engineer with extensive industrial experience and have been teaching at Wits since 1983. In 2001, I was appointed coordinator of first year students. My primary task was to redesign and run the first-year main-stream course "Introduction to Process and Materials Engineering" – termed "Process" by the students. The mandate for the redesign was to improve the academic performance of the entrants to the school by implementing appropriate development measures and integrating these with the engineering content of the Process Course. It quickly became evident to me that a long term view should be taken for achieving these objectives and that an action research mode of development was an appropriate methodology for doing so. Accordingly, I implemented an educational development project and launched the 'Engineering Educational Research Programme' in the school as structures to support and manage the research I thought was necessary. In addition, I sought and was granted ethical clearance for the project as a whole.

Since the initiation of the development project, a range of modifications to the Process Course have been made as well as a significant shift away from modes of teaching typically found in engineering education. These modifications and shifts have been reported elsewhere (Fairon, 2007; Kotta, 2006; Seabi, 2004; Woollacott, 2008; Woollacott, Henning, & Skuy, 2003). The way in which the teaching and learning difficulties associated with so called 'underprepared students' were problematized also shifted. The initial focus on student deficits moved to a more situated position and the notion that effective enculturation into engineering practice was a more appropriate way to conceptualize the objective of an engineering education curriculum in South Africa (Woollacott & Snell, 2006).

Student evaluations suggested that the modified course was well received by the students and their pass rates in the course have improved. However, in terms of improving the readiness of students for second and subsequent years of study, the modified course was less successful; first time pass rates in the follow-up engineering course declined. It appeared that the difficulty of achieving an academically successful transition from school to university was being shifted to the transition from the first to the second year of study. This "interface problem" has been noted and described by others (Pinto, 2001).

One of the studies I initiated within the broader development project in response to this disappointing result focused on the learning practices of students (Simelane, 2007). This was motivated by the observation that problematic features of the learning practices of many students seemed to persist through their first year of study despite the measures in the course that were intended to change those features. The Simelane study provided evidence in support of this observation and also provided useful detail about the nature of the problematic features and their impact on study at university. However, the general applicability of the study findings was somewhat limited because the student sample in the study was too small, too homogeneous and was not very representative of all entrants to the school. Accordingly, a more extensive and a more in-depth investigation into the learning practices of entrants to our programme was conducted in 2008. This thesis is the outcome of that study.

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

In 2004, the South African University Vice-Chancellor's Association (SAUVCA) published a volume entitled "Curriculum responsiveness: Case studies in higher education" (Griesel, 2004). The volume emerged from the long standing and on-going concern to address effectively the high attrition rates and academic underperformance of students in South African higher education (Letseka & Maile, 2008) as well as the mandate to transform the higher education sector in the country (Department of Education, 2007). The volume begins with a consolidation of theory about curriculum responsiveness that outlines four aspects of the concept (Moll, 2004). The first two – economic and disciplinary responsiveness – address the well-known requirement that an education program must address the needs which the labour market and disciplines (such as engineering) have for appropriately qualified graduates. The third aspect – societal responsiveness – is concerned with how educational programmes cater to the diversity of the culture at large and of the student intake in particular. The study presented in this thesis is associated with the fourth aspect – learner responsiveness – which has to do with how an educational program is "responsive to the learning needs of students by teaching them in terms that are accessible to them and assessing them in ways that they can understand" (Moll, 2004, p. 8).

Learner responsiveness implies that, in an educational programme, there is an on-going effort to understand better the characteristics and needs of the students entering that program as a basis for improving the educational strategies and environment that are deployed and for developing new and better ones. The characteristic that is investigated in this study is 'learning practices'. At the outset I use the term in a quite general way to refer to how an individual goes about and engages in studying and learning in the context of being a student at an institution of formal education such as a school, technikon, college or university. It is taken as self-evident that the quality of students' learning practices will have a significant influence on the quality of their academic performance. As will be demonstrated in the next chapter, much research evidence supports this claim (Biggs, 2003; Hounsell & Entwistle, 2005; Marton, Hounsell, & Entwistle, 1997; Prosser & Trigwell, 1999; Ramsden, 1985).

1.2 FOCUS OF THE STUDY

In South African engineering education, learner responsiveness is of critical importance particularly in the first year program. Attrition rates are high and there is a long history of bridging, foundation and extended programmes aimed at improving the academic performance of the students (Hillman, 1992; Pinto, 2001; Scott, Yeld, & Hendry, 2007; Woollacott et al., 2003). The factors which influence this academic under-performance and affect how teachers, curricula and institutions can or should respond appropriately are multidimensional, complex and inter-related in nature. This study focuses only on one aspect – the

influence of learning practices on student learning – and will concentrate on first year engineering students in general and on those entering chemical and metallurgical engineering at Wits in particular.

1.3 RATIONALE FOR THE STUDY

Although the way that students go about studying and learning are contextually sensitive (Prosser & Trigwell, 1999), they also have stable characteristics. As Dembo and Seli (2004) point out, "without realizing it, many students have probably automated their study habits through their repeated use during the 12 years of schooling prior to college" (p3). Entwistle contends that the ways students approach their learning

> "… are affected by their prior educational and personal histories, which produce habitual patterns of study. However, the content and context of a [learning] task evoke strategies which are specific to that particular situation. Both consistency, up to a point, and a certain variability, have thus to be incorporated into descriptions of student learning" (Entwistle, 1998p 43).

'Automated study habits' and 'habitual patterns of study' are characteristics which students bring with them to university. To the extent that they are perpetuated at university, these aspects of the students' ways of studying and learning will influence their academic performance at university. Clearly a good understanding of these 'habits' and 'patterns' and the extent to which they might change or be changed during the first year of study is important for the design of the first year curriculum.

A considerable body of research has investigated how the teaching and learning context can influence the way students learn and study (Biggs, 2003; Case & Marshall, 2009; Marton et al., 1997; Ramsden, 1985). Models of student learning have been developed from this research (see for example Prosser & Trigwell, 1999; Ramsden, 2003). These models consolidate research that shows, among other things, how students' prior experiences, conceptions of knowledge and of learning, orientations to learning, and reasons for studying affect how they respond to an educational context and affect the approach to learning which they adopt in that context.

For educational systems to be appropriately responsive to students, they must be based on a sound understanding of the relevant characteristics of the students (Prosser & Trigwell, 1999) – characteristics such as those which have been mentioned. In regard to engineering students in South Africa, we have inadequate knowledge of this kind. What we do have is either anecdotal (see examples given by Grayson, 1996; Meyer, Parsons, & Dunne, 1990), or is of limited applicability to students entering engineering education today. For example, investigations on first year engineering students at UCT in the early 1990's were conducted during the apartheid era (Meyer, 1991; Meyer, Cliff, & Dunne, 1994; Meyer & Muller, 1990; Meyer & Sass, 1993) and work by Case and associates involved second or third rather than first year students (Case, 2008; Case & Gunstone, 2002; Case & Marshall, 2004). The Simelane study mentioned in the prologue focused only on a sub-set of first year engineering students who were English additional-language speakers (Simelane, 2007).

In addition to the inadequacies just described, there have been relatively few interview studies with South African first year engineering students that aimed to obtain a rich and holistic insight into their experience and perceptions of studying and learning. The phenomenographic study by Marshall, Summers, & Woolnough (1999) focused narrowly on the conceptions of learning of engineering students in the context of a first year physics course. The studies by Meyer and associates were inventory studies and the only interview work conducted was either to establish the categories for the inventory instruments used (Meyer, 1988) or to confirm the categorizations that emerged from the studies (Cliff, 1996; Meyer et al., 1994). Some relevant interview studies have been conducted by Case and associates and by Simelane but, as already noted, these have limited applicability to the context of this study. My literature search found no recent interview studies in the country that focus both on a cohort of first year engineering students and also investigate how they go about studying and learning.

1.4 THE PROBLEM, THE AIM OF THE STUDY AND THE RESEARCH QUESTIONS

The unit of analysis in this thesis is the 'learning practices' of a student – the ways in which a student perceives, orients towards and engages in studying and learning. The general problem to be addressed is that our knowledge about the learning practices of first year engineering students in South Africa is inadequate and that this lack of knowledge is hampering efforts to improve their academic performance and to reduce attrition. Currently available research-based evidence does not provide sufficient insight to inform such efforts in a manner that indicates a way forward that is more effective than the measures currently in place.

The aim of the study is to address this problem by providing deeper insight into, firstly, the learning practices which first year engineering students have developed at school and therefore bring with them to university and, secondly, the learning practices they use and develop as they progress through their first year of study. Accordingly, the study addresses the following research questions; in these questions, the term 'our students' refers to first year chemical and metallurgical engineering students at Wits.

a) What is the qualitative variation in the learning practices of our students when they enter the university?

b) What is the qualitative variation in learning practices that they develop during their first year of study?

c) In what ways do our students perceive that their learning practices have changed during the course of the year?

1.5 THE SIGNIFICANCE OF THE STUDY

While some theoretical developments do emerge from this study, its primary objective is practical. By providing deeper insight into the learning practices of students entering South African institutions of

engineering education, the findings of the study have the potential to improve the design of developmental strategies that aim to improve the quality of student learning by facilitating an improvement in their learning practices. In addition, they could enable a better alignment of curricula and educational strategies to the kind of learners the students are. In other words, a deeper insight into how they go about studying and learning should lead to a deeper appreciation of the kind of learner responsiveness that is needed to optimize their learning. Better alignment and better informed developmental strategies should improve the academic performance of the students; i.e. the academic performance of students should improve if the curricula they encounter, the support systems they lean on, and the student development strategies that are provided for them are better aligned than they currently are to the way students go about studying and learning.

The significance of any study that could improve the academic performance of South African students entering higher education in South Africa becomes glaringly apparent when the magnitude of attrition rates due to academic failure is considered. The problem in South Africa is very serious indeed. This is demonstrated by the fact that, "in financial terms, [attrition] translates as a loss of about R4.5 billion in subsidies allocated to the higher education institutions by the state" (Media Brief, 2006). It is further demonstrated by a recent HSRC policy brief (Letseka & Maile, 2008) entitled, "High university drop-out rates: a threat to South Africa's future". The brief was disturbing not only in its title but in what it went on to say.

> "South Africa's university graduation rate … is one of the lowest in the world. Higher education also reflects broader inequalities with the graduation rate for white students being double that of [African] students … All role players in higher education should be concerned that nearly 14 years since the advent of democracy the promise of equality has yet to materialize." (p. 2)

Student graduation rates from all universities in South Africa are around 50% (Scott, 2008). In the country's university-level engineering schools, graduation rates are in the range from 50% to 70% (Pinto, 2001). Any study that has the potential of providing insights that could help to improve these dismal figures is highly significant.

1.6 STRUCTURE OF THE THESIS

The next two chapters review the literature from two perspectives. Chapter 2 focuses particularly on pinning down what is meant by and what is known about learning practices. Chapter 3 develops the theoretical background and the conceptual framework for the study and reviews literature relevant to that purpose. Chapter 4 outlines the research design and the methodological framework on which that design is founded. The six chapters which follow – Chapters 5 to 10 – present the results from the study. Chapter 11 draws these findings together and discusses their implications. Chapter 12 concludes the thesis by addressing the issues of the study's rigour and limitations, how the study findings resonate with the literature, and the theoretical developments that have emerged from the study. It also discusses the extent to which the findings have met the objectives of the study, and makes recommendations for further research.

CHAPTER 2: REVIEW OF LITERATURE ON LEARNING PRACTICES

2.1 OVERVIEW OF THE CHAPTER

The literature review in this chapter focuses on research into how students go about studying and learning particularly in the context of higher education. Findings relevant to an understanding of the nature of learning practices in general and among first year engineering students in South Africa in particular are reviewed. Literature related to the issues of the theoretical background and conceptual framework of the study is reviewed in the next chapter.

This study's interest in learning practices arises from the background of academic development efforts in South Africa. Accordingly, this chapter begins by briefly reviewing three different perspectives on the nature of those efforts and locates the study and this review in one of those perspectives. The review then addresses the general question of how the term 'learning practices' has been used in the literature. It then gives attention to three traditions that are prominent in research on student learning – Self-Regulation of Learning (SRL), Student Approaches to Learning (SAL) and inventory studies. The nature of these research traditions and of their findings on student learning is reviewed briefly after which the literature from one of the traditions – SAL – is reviewed in more detail with regard to findings that are relevant to a study on learning practices. Consideration is then given to research that has been conducted on how South African students go about studying and learning.

2.2 ACADEMIC DEVELOPMENT AND LEARNER RESPONSIVENESS

I begin this review by locating the study in the wider context of academic development efforts in South African higher education. The problem of high failure rates and academic underperformance in South African higher education has been conceptualized in different ways. Broekmann and Pendlebury suggest the various approaches fall within three broad categories as follows.

> "Academic development practice has moved from seeing students as the locus of the problem, to seeing academic institutions as the locus, and finally, to locating the problem in the relationship between student and institution. In the first phase, it was assumed that struggling students needed 'academic support'; in the second, it was argued that the institutions needed to change so as to accommodate diversity. While these two considerations still hold, now the focus for change is on the relationship between student and institution." (Broekmann & Pendlebury, 2002, p. 288)

The third phase of academic development described in this quotation has been defined elsewhere as learner responsiveness (Moll, 2004). Its mandate is to adapt or modify institutional structures and culture "to better fit the needs of increasingly diverse students" (Zepke & Leach, 2005, p. 46). Its emphasis on both student characteristics and institutional shortcomings is what distinguishes it from other approaches to academic development (Broekmann & Pendlebury, 2002). Stated a different way, a well-informed understanding of student characteristics is critical if institutional restructuring efforts are to be guided by

the idea of learner responsiveness. This review will focus only on student characteristics and only on their learning practices.

2.3 THE TERM 'LEARNING PRACTICES'

The literature does not use the term 'learning practices' in a clearly defined technical sense but as a gloss for ways in which people engage in and go about studying and learning (Gamache, 2002). Near synonyms to this general meaning do occur: for example 'learning behaviours' (Meyer, Dunne, & Sass, 1992), 'study behaviours' (Watkins, 1984), 'study habits' (Dembo & Seli, 2004), 'study orientations' (Meyer et al., 1990), 'study orchestrations' (Meyer et al., 1990), and 'learning orchestrations' (Hazel, Prosser, & Trigwell, 2002). Although each of these terms has the same general, non-technical nuance as 'learning practices', they are mostly used 'in passing' rather than as the focus of the study in which they occur.

What these terms mean and what they refer to depends on the perspective taken on student learning. Three perspectives are prominent in the research literature: self-regulated learning (SRL), students' approaches to learning (SAL), and inventory studies. From the perspective of the literature on SRL (self-regulated learning), the construct of 'learning practices' would refer to the processes and strategies that students use when studying as well as the conceptions, knowledge, beliefs, attitudes, and attributes that shape those processes. For example, Schunk and Ertmer (2000) describe self-regulation as follows:

> "Self-regulation comprises such processes as setting goals for learning, attending to and concentrating on instruction, using effective strategies to organize, code and rehearse information to be remembered, establishing a productive work environment, using resources effectively, monitoring performance, managing time effectively, seeking assistance when needed, holding positive beliefs about one's capabilities, the value of learning, the factors influencing learning, and the anticipated outcomes of actions, and experiencing pride and satisfaction with one's efforts." (p. 631).

The perspective of SAL (student approaches to learning), holds that the quality of learning outcomes achieved depends strongly on the 'approach to learning' which a student adopts. This perspective holds that the achievement of high quality outcomes is forthcoming when students adopt a 'deep' or meaning-orientated approach to learning. A deep approach is one that has both the *intention* of understanding and making sense of the material learned as well as the adoption of *strategies* suited to this intention (Case & Marshall, 2009; Prosser & Trigwell, 1999). This 'deep approach' contrasts with a 'surface approach to learning' where the focus is on the words in the text and the intention is to remember or reproduce the material for the purposes of satisfying externally imposed assessment of learning outcomes (Prosser & Trigwell, 1999). A student's learning practices, from an SAL perspective, would therefore have something to do with the intentions and strategies that lie behind the approach to learning which they typically adopt.

The third research perspective on student learning – inventory studies – adds nothing further to conceptions about the term 'learning practices'. As will be shown shortly, the inventory instruments used to investigate student learning are standardized questionnaires used to profile aspects of how students learn that are based on preconceived models or constructs derived primarily from SRL or SAL research.

In summary, 'learning practices' will be taken to refer to the web of processes, strategies, dispositions, and orientations developed from past experience which together influence how a student engages in studying and learning activities. A more specific definition of the term is given in Chapter 3 based on the more rigorous conceptual framework for the concept of 'learning practices' that is developed there.

2.4 RESEARCH PERSPECTIVES ON STUDENT LEARNING

In this section, the three research perspectives on student learning that have been mentioned are reviewed briefly. The intention is to highlight the essential differences between them and explain why the research approach behind the SAL tradition has been preferred in this study. In the section following this one, SAL research findings relevant to a study on learning practices are reviewed in more detail.

2.4.1 The SRL Perspective

The domain of research that has come to be known as 'self-regulated learning' research is rooted in cognitive psychology and is an approach to researching student learning that is particularly prominent in the USA. In brief, the SRL research tradition attempts to identify the cognitive processes and dispositions that influence the quality of student learning and to understand the dynamics and nature of that influence. The nature of these processes and dispositions has already been alluded to in Schunk and Ertmer's short summary given in the previous section. A fuller summary is embodied in the model of self-regulated learning which Zimmerman presents in the lead chapters to two of the seminal publications on SRL – (Schunk & Zimmerman, 1998; Zimmerman & Schunk, 2001). The model, depicted in Table 2.1, is widely recognized as encapsulating the essentials of these processes/dispositions in a coherent, integrated and reasonably comprehensive manner. The model distinguishes between what a student does before, during and after a learning engagement and indicates how processes such as goal setting, planning, monitoring, and adaptation are thought to be deployed by a student when learning and how these processes are mediated by the student's dispositional attributes such as their beliefs, level of interest, self-efficacy, motivation and attributions. Research in the SRL tradition focuses on one or more of the processes/dispositions mentioned in the table and attempts to understand the dynamics, cognitive processes and influences that are involved in the execution of the processes in question and how different levels of execution skill affect the quality of the learning achieved. In this way, the attempt is made to distinguish between skillful, naive or ineffective self-regulation with higher quality learning outcomes being associated with more skillful regulation of learning (Zimmerman, 1998).

Table 2.1: A General Model of Self-Regulated Learning

Compiled from Zimmerman (1998, pp. 2-7)

Forethought "Influential processes/beliefs that precede efforts to learn and set the stage for such learning."	**Performance or volitional control** "Processes that occur during learning efforts and affect concentration and performance."	**Self-reflection** "Processes that occur after learning efforts and that influence a learner's reactions to that experience"
Processes ***Goal setting***: "Deciding on specific outcomes of learning". ***Strategic planning***: "Selection of learning strategies to attain the desired goals". **Beliefs and Dispositions** ***Self-efficacy***: "Personal beliefs about one's capability to learn and perform at certain designated levels." ***Goal orientation***: "Learning [progress] or mastery orientation vs "performance or ego-related goal orientation". ***Interest in learning tasks***: Intrinsic or extrinsic	***Attention focusing***: Protecting intentions to learn from distractions. ***Self-instruction***: "Telling one-self how to proceed during a learning task." ***Self-monitoring***: "Informs learner about progress or lack of it."	***Self-evaluation***: "Comparing self-monitored information against some sort of standard or goal." ***Attributions***: Whether outcomes of self-evaluations (eg. failed or succeeded) are attributed to one's effort or to one's ability. ***Self-reactions***: How outcomes of attributions affect consequential adjustments to strategy use and learning effort. ***Adaptation***: How attributions and self-reactions work together to iteratively adapt forethought, regulation strategies and dispositions until the learner "finally discovers the strategy that works best for [him/her]."

Two characteristics of the SRL research tradition make it an approach that is not suited to the objectives of this study: its position with regard to the proactive nature of learning; and the fact that it views student learning from the perspective of *a priori* theoretical models. These issues are discussed further in turn.

With regard to the proactive nature of student learning, the SRL tradition views learning "as an activity that students do for themselves in a proactive way rather than as a covert event that happens to them in reaction to teaching" (Zimmerman, 2002, p. 65). Zimmerman emphasizes the proactive side of learning as follows: "students are self-regulated to the degree that they are meta-cognitively, motivationally, and behaviourly active participants in their own learning process … [and] self-generate thoughts, feelings, and actions to attain their learning goals" (Zimmerman, 2001, p. 5). While it seems undeniable that learning does involve the kind of proactivity just described, the SRL tradition's emphasis on the proactive nature of learning seems to go too far and to be such that it overlooks – even excludes – the possibility that learning may also involve intuitive and automated processes as well. Chapter 3 makes the case that non-proactive processes may be as influential on the quality of student learning as proactive processes if not more so.

With regard to *a priori* models, the deductive nature of SRL research into student learning is made particularly clear by Winnie and Perry (2000). They point out that the experimental protocol used in SRL research begins with the development or refinement of a theoretical model of some aspect of the cognitive processes thought to be important in student learning, followed by obtaining appropriate measures of those

processes together with measures of the learning outcomes or behaviours thought to be influenced by those processes. This is followed by a statistical examination of the degree of correlation between the measures in an effort to investigate causal connections between them. In other words, self-regulated learning processes are viewed from the perspective of *a priori* theoretical models. While the experimental procedure described has provided interesting and detailed insights about aspects of the dynamics of studying and learning, the insights take the form of models rooted in cognitive psychology and are dependent on the relevance or appropriateness of those models. From the perspective of our students and the context of this study, the relevance of those models is uncertain and the degree to which they address the factors that most influence our students' learning is even less certain. Accordingly, insights from the SRL research tradition are not reviewed in more detail here and are not considered further in this study.

2.4.2 The Perspective of Inventory Studies

The idea behind an inventory study is to use a standardized survey questionnaire to obtain quantitative measures (subscale scores) that together provide a profile of aspects of how a student goes about studying and learning. This profile is quantitative in nature in that a subscale score is developed for each aspect probed by the instrument and the pattern of scores is interpreted in order to reach conclusions about how students go about learning.

Typically, the questionnaire – the inventory instrument – consists of a set of carefully worded statements each of which a student responds to, usually on a five point Likert Scale, by indicating the extent to which they do or do not relate to the statement (Biggs, 1993; Cohen, Manion, & Morrison, 2007; Entwistle & McCune, 2004; Richardson, 2004). The statements are designed to probe preconceived constructs or aspects of models of student learning and the student's responses are interpreted accordingly. Entwistle and McCune (2004) have compiled and compared a number of inventory instruments that have been commonly used.

While there is much that is appealing about inventory studies (eg. profiles of large numbers of students can be obtained quickly and easily, and the profiles obtained are quantitative in nature and so are amenable to statistical analysis), the reductionism that is implicit in the methodology has some problematic implications (Case & Marshall, 2009; Gamache, 2002; Haggis, 2003, 2006, 2009; Marshall & Case, 2005). In particular, inventories are based on preconceived constructs and/or *a priori* models. This means that inventories instruments are only able to describe student learning in terms of these models/constructs. Consequently, they are somewhat rigid in nature and are unable to investigate important qualitative detail and nuances (Marshall & Case, 2005) that may be important in trying to understand "the messy and complex realities of individual teaching and learning situations" (Haggis, 2003, p. 95). Put another way, they are not able to generate fresh insights or constructs; they merely operationalize in a quantitative manner qualitative insights that have already been developed. In addition to these shortcomings, questions have been raised about how accurate or meaningful quantitative subscale measures from inventory instruments actually are (Case, 2004; Haggis, 2003; Mitchell, 1994, 2000). Because of these problematic

features, the perspective on learning practices which inventory studies provide is not reviewed in detail here and is not considered further in this study.

2.4.3 The SAL Perspective

The domain of research that has come to be known as 'student approaches to learning' research differs from the SRL domain in a number of ways. Firstly, it is associated more with the work of educationists where SRL research is associated more with the work of cognitive psychologists. Secondly, the SRL tradition is prominent in the USA whereas the SAL tradition is prominent outside the USA; its origins can be traced to Sweden, Britain and Australia (Biggs, 2001; Case & Marshall, 2009). However, the most characteristic difference is that SAL research investigates student learning from a second order perspective – that is from the perspective of the students. This inductive approach contrasts with the deductive perspective of the domain of self-regulated learning with its grounding in *a priori* cognitive models. Dahlin (2007) explains the difference in terms of "studying conceptions of reality" (the second-order perspective) compared to studying reality itself (p. 328) or models of that reality (the first-order approach).

The rationale for researching student learning from a second-order perspective is the notion that perceptions shape activity – that students act on reality according to the perceptions they have of it (Marton & Booth, 1997). Therefore, to gain insight into what influences student learning, research from this perspective seeks to understand the ways in which students perceive and relate to relevant aspects of learning. The theoretical underpinnings of this research domain and the methodology on which it is based – phenomenography – are discussed in some detail in Chapter 3 along with a consideration of the criticisms which have been directed at the SAL perspective on student learning.

The hallmark finding of SAL research, as summarized in section 2.3, is that the quality of learning outcomes which students achieve depends strongly on the 'approach to learning' which they adopt. This association between approaches adopted and learning outcomes achieved has been attested over a wide range of contexts (see in particular the two meta-analyses by Hattie, Biggs, & Purdie, 1996; and Watkins, 2001) with high quality outcomes being associated with the adoption of 'deep' or meaning-orientated approaches to learning and lower quality outcomes being associated with the adoption of 'surface' or reproduction-oriented approaches to learning. More generally, a deep approach to learning resonates with the aims of higher education (Case & Marhsall, 2009, p.12 citing Barnett, 1990) and with how teachers would like students to engage with learning tasks and situations. Put another way, the deep-surface contrast emerging from SAL research corresponds with the contrast between desirable-undesirable or appropriate-inappropriate learning engagements (Meyer, 1991) or "engaging the task properly on its own terms" as compared to engagements that are "extrinsic to the real purposes of the task" (Biggs, 1993, pp. 6-7; 2001).

The finding that the quality of learning outcomes depends on the type of approach to learning adopted has oriented much of the research in the SAL tradition towards understanding, on the one hand, what distinguishes a deep from a surface approach in different learning contexts and, on the other, what it is that

influences whether students adopt surface or deep approaches (Hounsell & Entwistle, 2005; Marton et al., 1997; Prosser & Trigwell, 1999). For example, studies have reported that the approaches to learning which students adopt in particular learning situations are influenced by their perceptions of the learning context (Entwistle, 2003; Prosser & Trigwell, 1999; Ramsden, 2003) as well as by their conceptions of knowledge and of learning (Entwistle, 2009; Entwistle & McCune, 2004; Marshall et al., 1999; Marton, Dall'Alba, & Beaty, 1993; Saljo, 1979), their reasons for studying (Beaty, Gibbs, & Morgan, 1997), and their prior educational experience (Ferla, Valcke, & Schuyten, 2009; Prosser & Trigwell, 1999; Ramsden, 2003). Some of these influences are external to the student – for example the nature of the learning context (Lizzio, Wilson, & Simons, 2002), while some are student characteristics that derive from their educational experience – for example their conceptions of knowledge and experience of learning contexts, and their orientation to studying (Ramsden, 2003).

The findings from SAL research have been consolidated into models of student learning by several researchers (Biggs, 1978; Entwistle, 2003, 2004; Prosser & Trigwell, 1999; Ramsden, 2003). In one way or another, these models follow the classic '3P' model of student learning by Biggs (1978) – where '3P' stands for 'presage, process and product'. As can be seen in the two versions of this model depicted in Figures 2.1 and 2.2, the model posits that the 'product' from learning situations (the learning outcomes achieved), are influenced by 'processes' that occur during the learning situation (the interpretation of the learning task – how it is perceived – and the approach to learning adopted in the learning situation) which in turn are influenced by 'presage' factors such as the student characteristics and the characteristics of the learning context.

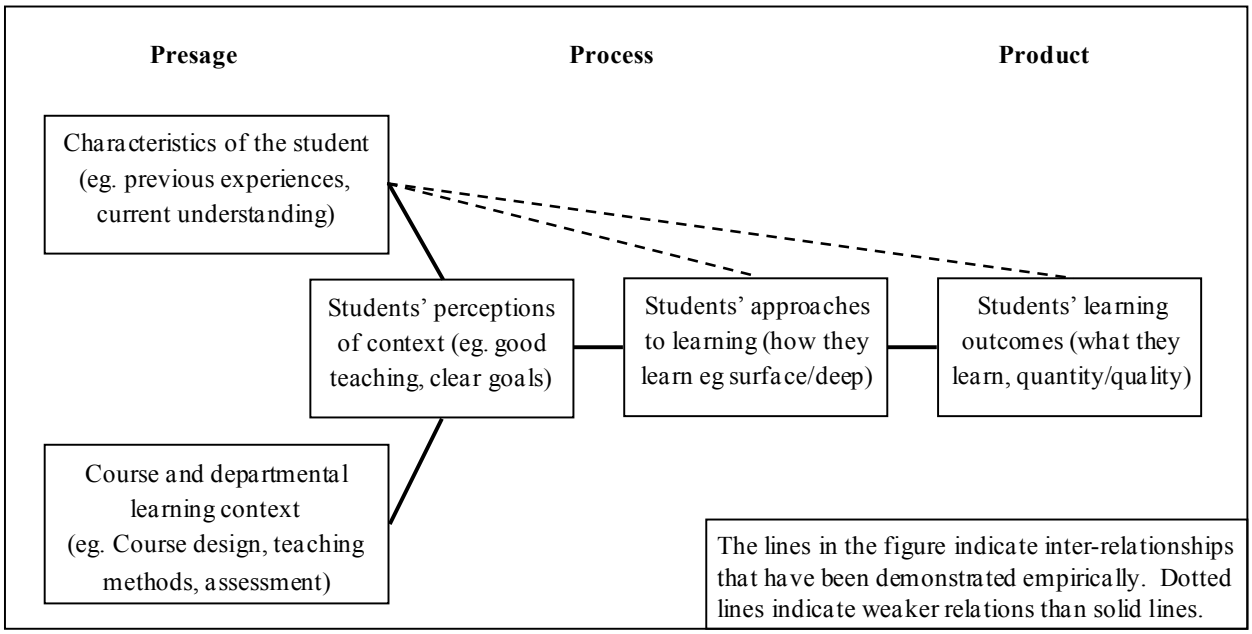


Figure 2.1: Prosser and Trigwell's Version of the Model of Student Learning

(Prosser & Trigwell, 1999, p. 12)

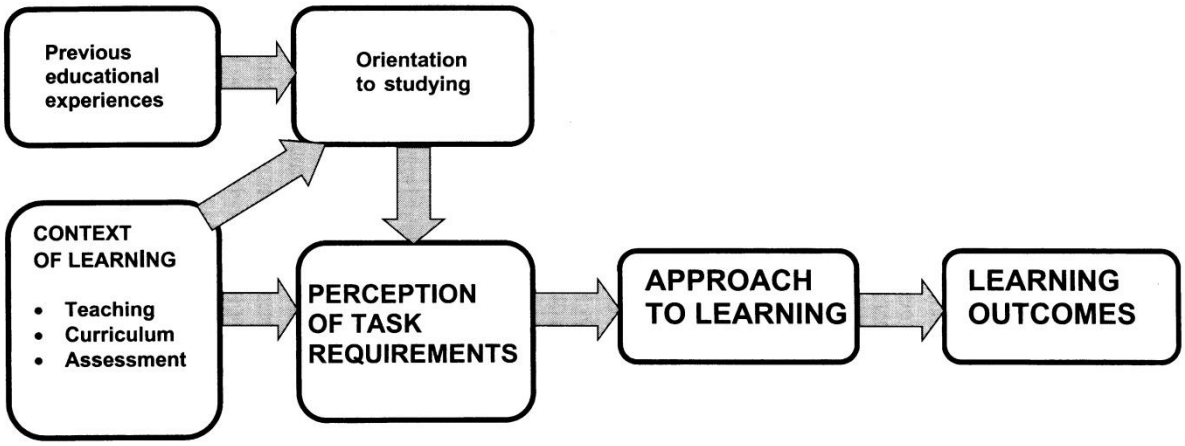


Figure 2.2: Ramsden's Version of the 3P Model of Student Learning

(Ramsden, 2003, p. 82)

The 3P model and its variants are different from the models developed in the SRL tradition in several respects. Apart from the obvious difference in emphasis (the emphasis on approaches to learning as opposed to the regulation of learning), SAL models are grounded models; they derive from research findings rather than being *a priori* theoretical models that precede an investigation of how students go about learning. As such, new research from an SAL perspective does not start from an SAL model of learning; it does not even start from the perspective of approaches to learning. It starts from the second order perspective of investigating how students relate to whatever aspect of learning is the focus of the investigation. Given its grounded nature combined with the uncertainty about the relevance of any existing model of student learning to the context of our students, this second order research approach was the one selected for this study. Accordingly, the literature reviewed in the rest of this chapter focuses primarily on SAL findings that have emerged from this second order research approach. The review is selective and focuses only on issues relevant to a study on learning practices.

2.5 SAL FINDINGS AND THE NATURE OF LEARNING PRACTICES

According to the working definition given at the end of section 2.3, learning practices are a web of processes, strategies, dispositions, and orientations which a student has developed from past experience and may influence how that student engages in studying and learning activities in the present. Approaches to learning do not constitute learning practices as such because they are evoked in the moment of engaging in learning activities (Prosser & Trigwell, 1999; Trigwell & Ashwin, 2002) rather than being processes, strategies etc. developed by prior experience. However, approaches to learning do influence the nature of learning practices in that the adoption of a particular approach to learning in a particular set of circumstances constitutes an experience and that experience adds to a student's repertoire of past experience and hence affects their practices. Accordingly, factors that influence approaches to learning are likely to influence the nature of learning practices. The review in this section therefore focuses on insights

from the SAL literature with regard to the nature of approaches to learning and the factors that influence them.

2.5.1 The distinction between deep and surface approaches to learning

Perhaps the most prominent feature of the SAL perspective on student learning is the issue of whether the way a student relates to a particular learning situation is 'deep' or 'surface' in nature. Earlier it was stated that while the classic distinction between deep and surface approaches to learning has to do with the contrast between learning for understanding and learning for reproduction, more generally the distinction has come to be recognized in terms of appropriate or effective ways of engaging with learning tasks (deep approaches) in contrast to ineffective or less inappropriate ways of engaging (surface approaches) (Biggs, 1993, 2001; Case & Marshall, 2009). What constitutes a more or a less appropriate way to engage with a learning task involves more than the issue of whether learning is oriented to understanding or to the reproduction of information. For one thing, it depends on the disciplinary area. As Ramsden puts it, "since typical tasks vary between different disciplines, we find that the way in which approaches [to learning] manifest themselves also varies" (Ramsden, 2003, p. 49). Similarly, Entwistle, in the recently completed ETL project (Enhancing Teaching-learning Environments) (Entwistle, 2003; Hounsell & Entwistle, 2005), highlighted how the surface-deep distinction translates differently in different course contexts with each discipline having its own "inner logic of the subject and its pedagogy" (Entwistle, 2009, p. 3) and being associated with its own unique "ways of thinking and practicing" (McCune & Hounsell, 2005).

While studies that investigate the influences on students' approaches to learning may assume the surface-deep distinction as an adequate differentiation of the ways students go about learning (Prosser & Trigwell, 1999, gives several examples of this), the more fundamental SAL studies do not start from this position; they focus on the variation in the ways students relate to the aspect of learning being investigated without any preconceived idea about whether these ways may be surface or deep in nature. Although these ways of relating may subsequently be interpreted in terms of the surface-deep distinction, this is a *post facto* interpretation that is based on an evaluation of the degree of appropriateness of the ways of relating which an investigation identifies. This point is demonstrated very clearly in the study by Booth (1992) on how students go about learning to program. That study identified four qualitatively different ways in which students related to the task of writing computer programs – expedient, constructual, operational and structural approaches. The first two of these approaches were recognized to be 'surface' in nature in that they were less adequate ways of learning to programme compared to the latter two approaches which were consequently recognized to be more 'deep' in nature.

On the basis of these observations, the distinction between deep and surface approaches to learning is seen to be a rather coarse-grained distinction and is one which is made on the basis of more fine-grained distinctions between different ways in which students relate to some aspect of learning. From the perspective of learning practices, it is these fine-grained distinctions that are of particular interest.

2.5.2 More fine-grained insights into the nature of approaches to learning

Table 2.2 presents descriptions of approaches to learning reported early in the SAL literature. Apart from elaborating what was understood at the time to be the distinguishing features of deep and surface approaches, it describes a third approach – a strategic approach to studying. Biggs (1987) originally labelled this as an 'achieving approach' because he understood the intention behind it to be to maximize the marks obtained in a course. However, it has become more common to recognize this third approach not as a distinct approach to learning that is different from deep and surface approaches, but as an approach to studying that involves an organization of study effort based on what students anticipate is most appropriate for the kind of assessments they will encounter; some aspects of a course are studied 'more deeply' for understanding while others are studied more 'superficially' for recall of information based on perceptions about how each aspect will be assessed (Case & Marshall, 2009; Entwistle, 2003, 2009; Volet & Chambers, 1992).

Table 2.2: Characteristic Features of Surface, Deep and Strategic Approaches to Learning
(From Entwistle, McCune, & Walker, 2001, p. 109)

Deep Approach - Seeking Meaning ***Intention*** : to understand for oneself ***By***: Relating ideas to previous knowledge and experience, Looking for patterns and underlying principles, Checking evidence and relating it to conclusions, Examining logic and argument cautiously and critically, Being aware of understanding developing while learning, Becoming actively interested in the course content.
Surface Approach - Reproducing ***Intention***: to cope with course requirements ***By***: Treating the course as unrelated bits of knowledge, Memorising facts and carrying out procedures routinely, Finding difficulty in making sense of new ideas presented, Seeing little value or meaning in either courses or tasks set, Studying without reflecting on either purpose or strategy, Feeling undue pressure and worry about work.
Strategic Approach - Reflective Organising ***Intention***: to achieve the highest possible grades ***By***: Putting consistent effort into studying, Managing time and effort effectively, Finding the right conditions and materials for studying, Monitoring the effectiveness of ways of studying, Being alert to assessment requirements and criteria, Gearing work to the perceived preferences of lecturers.

The format Entwistle et al. used to describe the three approaches outlined in Table 2.2 illustrates a feature of SAL findings that derives from the second order perspective used in SAL research – the importance of giving attention to both intention and strategy (or way-of-acting) when trying to understand how students relate to an aspect of learning (Biggs, 1987, 2001; Marton, 2000; Marton & Saljo, 1976). Failure to give adequate attention to both intention and strategy has sometimes led to confusion when trying to understand the nature of particular aspects of student learning. One example of this is the issue of memorization when studying. (As will be seen later, this is an issue that is very relevant to this study.) As indicated in Table

2.2, the practice of memorization was originally recognized as being indicative of a surface approach to learning in that the intention behind memorization was understood to be the reproduction of information in tests. However, studies with Chinese students (Marton, Watkins, & Tang, 1995) indicated that memorization could also be associated with an intention to understand and, when that is the case, is indicative of a deep approach to learning (Marton & Booth, 1997; Marton et al., 1995). Accordingly, memorization as a study strategy can be indicative of either a surface or a deep approach to learning and reference must be made to the intention behind the strategy in order to discern which type of approach has been adopted.

The work with Chinese students and memorization led to the interesting perspective on student learning presented here as Table 2.3. The perspective is considerably more detailed than the 3P model. Its focus on the nature of learning is more finely graduated (paying attention to words, meanings, and phenomena); attention is given to the temporal phases of learning (acquiring it, retaining it, and using it); and attention is also given to the agent of learning (self or teacher), the act of learning, and the object of learning. Apart from the extra detail it includes compared to the 3P model, the perspective also suggests that a spectrum of approaches may be a more appropriate way to understand how students relate to learning than the classic surface–deep dichotomy – a suggestion endorsed by Case and Marshall (2009). In this regard, it is evident that categories 2 to 4 in the table are all 'meaning-oriented' and in this respect are to some degree 'deep' in nature but the depth of understanding achieved is graduated – it progresses from meanings to the understanding of meanings to the understanding of phenomena.

Table 2.3: A Model of Learning Which Involves Memorization
(From Marton et al., 1995 cited in Marton & Booth 1997, p. 43)

Ways of experiencing learning	Temporal dimension of learning		
	Acquiring	Knowing	Making use of
1. Committing words to memory	Memorising words	Remembering words	Reproducing words
2. Committing meanings to memory	Memorising meanings	Remembering meanings	Reproducing meanings
3. Understanding meanings	Gaining understanding (of meanings)	Having understanding (of meanings)	Being able to do something Being able to do something differently Being able to do something different
4. Understanding phenomena	Gaining understanding (of phenomena)	Having understanding (of phenomena)	Relating [the phenomena to other phenomena in the world]
Depth dimension of learning		An intertwining of the following aspects of learning a) the agent of learning b) the act of learning c) the object of learning	

Other refinements to the surface-deep distinction have been reported by Case and Marshal and Crawford et al. with regard to contexts that involve problem solving. Case and Marshall (2004), in studies

with science and engineering students, identified two 'intermediate' approaches to learning between surface and deep: a 'procedural surface' or 'algorithmic' approach which has the intention of being "able to solve problems in [a] test/examination" by "identifying and memorizing calculation methods for solving problems"; and a 'procedural-deep approach' which involves the intention "to gain understanding at some future point through familiarity with applications and problem-solving procedures" by "relating formulae to each other, or parts of algorithms to other parts" (p. 609). Crawford et al. (1994), in studies with students in maths courses, developed a similar but still more fine-grained view of how students related to learning situations involving problem solving. This view involved the 5 approaches described in Table 2.4 and shows a progression in the sophistication of the intentionality behind the working of problems and a progression in the degree to which the working of problems facilitates a deeper understanding of the relevant theory.

Table 2.4: Approaches to Learning Mathematics
(From Crawford et al., 1994, p. 337)

1. Learning by rote memorisation, with an intention to reproduce knowledge and procedures.
2. Learning by doing lots of examples, with an intention to reproduce knowledge and procedures.
3. Learning by doing lots of examples with an intention of gaining a relational understanding of the theory and concepts.
4. Learning by doing difficult problems with an intention of gaining a relational understanding of the entire theory, and seeing a relationship with existing knowledge.
5. Learning with the intention of gaining a relational understanding of the theory and looking for situations where the theory will apply.

While the refinements just described derive from paying attention to how students relate to learning when the context involves problem solving, other refinements have been identified in studies that paid attention to how students relate to the development of understanding. For example, in early work, Entwistle (1988) distinguished between active and passive dimensions of surface or deep approaches when students are reading academic articles. The four categories he identified, indicated below, constitute a four-step progression in the degree to which the approach to learning is committed to understanding the meaning and argument of an article being read.

Surface-Passive approach:	After a keen start, loses interest and doesn't think about what is being read.
Surface-Active approach:	Looking out mainly for facts and examples but not concentrating on interpretation.
Deep-Passive approach:	Extracting the underlying meaning but overlooking facts/examples.
Deep-Active approach:	Looking for the meaning, concentrating on arguments and supporting evidence.

(Entwistle, 1988, p. 78 cited in Entwistle, 2009, p. 34)

A more recent study investigated the variation in how medical students went about developing their understanding (Fyrenius, 2007). The study distinguished between merely working with acquired information (sifting and condensing it) and building a personal understanding through reorganizing the information, looking for connections, and "striving for a change in perspective" (p. 155). This 'building process' is similar to what Entwistle et al. describe as the construction of 'knowledge objects' – "tightly

integrated, quasi-visual, [and quasi-sensory] forms of understanding" (Entwistle & Entwistle, 2003, p.19; the insert in square brackets is taken from Entwistle, 1997, p.146).

Findings by Entwistle et al. with regard to 'knowledge objects' derive from their study on how a group of students had experienced the development of their understanding when involved in intense revision for final examinations (Entwistle, 2009; Entwistle & Entwistle, 1991, 2003; Entwistle & Marton, 1994). That study yielded other interesting insights. It showed that the quality of understanding achieved by the students was influenced by the amount of material that was integrated when studying; "the amount of effort put into establishing patterns of relationship"; and "the extent to which the understanding had been independently constructed" (McCune & Entwistle, 2011, p. 304). Also, influential was the kind of structure used to organize the material being learned. Table 2.5 lists the 5 categories of structure that were identified in the study. The categories show a progression in the degree to which students structured their understanding when learning, and a progression in the extent to which they relied on their personally constructed understanding of the material being studied.

Table 2.5: Structures Used to Organize Material Being Learned When Preparing for Final Examinations
(Entwistle & Entwistle, 1997, pp. 148-150)

1)	Little or no structure being imposed on the facts learned.
2)	Relying exclusively on the lecturer's structures.
3)	Producing prepared answers to previous years' questions.
4)	Adapting own understanding to expected question types.
5)	Relying on their individual conception of the topic.

The review so far has focused mainly on the nature of approaches to learning as reported in the SAL literature with the understanding that a student's learning practices derive primarily from how they have approached (engaged in) studying and learning in the past. The next subsection looks at this understanding in more detail by reviewing literature relating to the relationship between approaches to learning and orientations to learning.

2.5.3 Approaches to learning and orientations to learning

The SAL literature is very clear that an approach to learning is something that is *evoked* in the moment of engaging with a learning task (Prosser & Trigwell, 1999; Trigwell & Ashwin, 2002) and that the way a student perceives a learning context and how they interpret the demands of a learning situation exerts a strong influence on the approach to learning that is evoked. Much research evidence supports this contention to the extent that a strong consensus has emerged that a student's perception of a learning context is the primary factor determining the approach to learning they adopt in that context (Biggs, 2003; Bowden & Marton, 1998; Case & Marshall, 2009; Entwistle, 2009; Marton et al., 1997; McCune & Entwistle, 2011; Ramsden, 2003; Trigwell, 2010). As both versions of the 3P model indicate (Figures 2.1

and 2.2), the consensus regards other factors as exerting only an indirect influence and that this influence is exerted by the way these factors affect a student's perception of the learning context.

Despite the consensus about the context sensitivity of approaches to learning, there is also evidence of a degree of consistency in the approaches students adopt – that they may also have a particular 'orientation to learning', a tendency towards adopting a particular approach. Ramsden (2003) put it this way.

> "Although it is abundantly clear that the same student uses different approaches on different occasions, it is also true that general tendencies to adopt particular approaches, related to different demands of courses and previous educational experience, do exist. Variability in approaches thus coexists with consistency." (p. 51)

Ramsden appears to regard an 'orientation to learning' as a 'general approach to learning', a propensity "to address a range of different learning tasks … in a certain way" (p. 51). This is a little confusing and somewhat inconsistent with the consensus that an approach to learning is evoked as a consequence of how the learning situation is perceived. However, Biggs (2001) is clearer in his view and considers an 'orientation to learning' as a tendency developed as a result of prior experience. Put another way, past experience of approaching and engaging in learning in particular ways develops an orientation or repertoire of orientations to learning in those particular ways. As such, an orientation to learning is the result of an accumulation of experiences of approaching and engaging in learning activities in particular ways. This resonates with the earlier working definition of learning practices – i.e. a web of processes, strategies, dispositions etc. developed from prior experience which together influence how a student goes about learning.

2.5.4 Learning practices and orientations to learning

It seems from Ramsden's analysis of the influences on approaches to learning, as described in his version of the 3P model (Figure 2.2), that orientations to learning should be regarded not only as the accumulation of past experiences of approaches to learning but as embodying the combined influence of all aspects of prior experience including experiences of learning contexts. From Prosser and Trigwell's version of the 3P model (Figure 2.1) it would seem that the influence of student characteristics and dispositions should also be considered to be embodied aspects of orientations to learning. If so, the correspondence between the constructs of learning practices and orientations to learning is seen to be very close indeed.

The line of thought that orientations to learning embody the combined influence of prior experience and student characteristics is not argued in the SAL literature very strongly and this appears to be an area that is somewhat under-researched. The reason for this seems to be that the influence of prior experience and student characteristics on approaches to learning has been found to be less significant than the influence of students' perceptions of learning (see Figure 2.1). Prosser and Trigwell (1999) go as far as claiming that a student's perceptions of a learning context can "totally override" the influence of the learning orientation they have developed from their prior experience. They cite several studies in support of this contention (Eley, 1992; Gibbs, 1993; Laurillard, 1979, 1997) and state the following.

> "While there is evidence that students do have a learning orientation (here they cite Entwistle & Ramsden, 1983) there is now also sufficient evidence that a student's orientation can be totally overridden by his or her

> perceptions of the demands of the learning task. … The same student will adopt qualitatively different approaches in different contexts." (p. 98)

In the light of this reasoning, it is not surprising that SAL research has focused more on investigating the influence of contextual factors with the expectation that the findings will guide efforts to modify pedagogies, and teaching and learning environments appropriately (Evans & Kozhevnikova, 2011; McCune & Entwistle, 2011; Trigwell, 2010). For example, Ramsden's research identified five contextual factors as having a strong influence on approaches to learning – workload, the flexibility of learning tasks, the clarity of learning goals, the kind of assessment used, and the quality of teaching (Ramsden, 1979, 1991, 1997; Entwistle & Ramsden, 1983). Research of this kind has been bolstered by the perception that efforts to improve student learning by crafting learning environments that evoke deep approaches to learning is likely to be more effective in improving student learning than efforts to 'change students' or their dispositions or learning practices in some way (see, for example, Prosser & Trigwell, 1999, especially chapter 3). This perception persists despite the awareness that it is relatively easy for a teaching environment to evoke surface approaches to learning but much more difficult to craft environments that successfully evoke in the majority of students deep approaches to learning (Ramsden, 1997).

While many researchers hold that the perceptions of the learning context is the dominant factor influencing student learning to the extent that these perceptions can 'totally override' the influence of prior educational experience, the reverse has also been widely reported – that prior educational experience can 'totally override' the influence of learning contexts (Brownlee, Purdie, & Boulton-Lewis, 2001; Case & Gunstone, 2002; Dembo & Seli, 2004; Meyer, 1991; Meyer et al., 1992; Rodriguez & Cano, 2006; Vermetten, Vermunt, & Lodewijks, 2002; Yuksel, 2006). Even in learning contexts that have been specifically designed to evoke in students the adoption of deep approaches to learning by deploying 'powerful learning environments' (Vermetten et al., 2002) or 'high-impact educational practices' (Kuh, 2008), there have been reports of students continuing to adopt surface approaches to learning because their existing learning behaviours appeared to be remarkably stable and resistant to change (Brownlee et al., 2001; Hazel et al., 2002; Vermetten et al., 2002). This implies that, whatever else might influence the quality of student learning, the influence of prior educational experience should not be overlooked. In particular, learning practices developed at school may be deeply ingrained and can potentially exert a powerful influence not only on the learning practices students deploy at university (Dembo & Seli, 2004; Entwistle, 1998; Hofer, Yu, & Pintrich, 1998) but also on their perceptions of the learning contexts they experience there and how they respond to those contexts.

2.5.5 Summary of the review of learning practices in general

Up to this point, the review has focused on the international literature. Before looking at literature that relates more specifically to South African students, a brief summary of what has emerged from the review so far is appropriate.

For a university to exercise learner responsiveness, it must pay attention to how its students respond and relate to the teaching and learning environment which it maintains. The SAL research perspective appears

to be better suited to such an endeavour compared to the alternative SRL and inventory study perspectives particularly when the manner in which students go about learning is not well understood. The second-order perspective, which undergirds the SAL methodology, focuses on how students relate to studying and learning and pays attention to both the strategy used and the intention behind it. Evidence shows that, in general, when students relate in ways appropriate for effective learning – when they take a deep, meaning-oriented approach to learning – the learning outcomes achieved are superior to those achieved when their approach is more superficial in nature. This rather coarse-grained distinction between deep and surface approaches needs to be elaborated in specific contexts in order to gain a more fine-grained insight into how students relate to learning in those contexts. In this regard, elaborations relating to the general contexts of assessment, problem-solving, memorization, and achieving understanding have been reviewed.

While an approach to learning is something that is evoked in the moment, the experience of approaching learning in particular ways develops an orientation to learning in that way and, together with other aspects of past experiences and student characteristics, influences, either directly or indirectly, the approach to learning adopted in subsequent engagements with learning situations. As such, orientations to learning are synonymous with learning practices. There is disagreement about the extent to which orientations to learning (learning practices) influence approaches to learning directly – i.e. the idea that students adopt particular approaches simply because they have done so in the past. However, there is evidence that, in some cases, this direct influence is strong because orientations to learning are stable and resistant to change and can defeat attempts to facilitate the adoption of deep approaches to learning by organizing the learning environments with that purpose in mind.

2.6 THE LEARNING PRACTICES OF SOUTH AFRICAN ENTRANTS TO ENGINEERING EDUCATION

In view of the adverse effects of the legacy of apartheid education in South Africa, and of the on-going problematic nature of pre-tertiary education in the country (Letseka & Maile, 2008; Muwanga-Zake, 2005; Phurutse, 2005; Scott et al., 2007; Simpkins, 2005; Yeld, 2003), it would be surprising if the learning practices of many South African school leavers did not include features that are problematic in a university context. The content of South African academic support programmes (Pinto, 2001) and anecdotal information (Grayson, 1996; Meyer et al., 1990; Meyer et al., 1992) refer to various problematic features such as ‘rote learning’ and various so-called “learning pathologies” (Meyer, Parsons, & Dunne, 1990). Studies with South African engineering students have paid attention to ‘pathologies’ such as disorganized study methods, syllabus boundedness, “an uncritical reliance on the words of the teacher or textbook while ignoring other aspects of the teaching/learning relationship”, “an inability to see the relationships between ideas or concepts”, “a failure to integrate detail into an overall picture and an overcautious reliance on detail and procedure”, and “an inability to back up a general picture with the necessary detail, leading to unsubstantiated conclusions and the use of irrelevant material” (Meyer et al., 1992, pp. 313-315).

In the mid-1990s, when the introduction of new support and developmental measures in South African higher education was at its height, Grayson lamented that relevant, research-based knowledge about the characteristics of school leavers entering higher education in South Africa was either lacking or undocumented. Accordingly, she had to base the design of a science foundation programme largely on anecdotal information and on general educational principles (Grayson, 1996). Since then work has been done to advance our understanding about students' learning practices, 'gaps' (Mumba, Rollnick, & White, 2002; Rollnick, Manyatsi, Lubben, & Bradley, 1998), language proficiency (Maree & De Boer, 2003; Miller, Bradbury, & Wessels, 1997; von Gruenewaldt, 1999), and the provision of effective academic support for disadvantaged students (Rollnick, 2010). In regard to students' learning practices, the most extensive work has been done by Meyer and associates in the early 1990s and, more recently, by Simelane (2007). These two bodies of work are reviewed next. Other research – for example by Case and Marshall (2004); Davidowitz & Rollnick (2003); Kloot, Case, & Marshall (2008); Rollnick, Davidowitz, Keane, Bapoo, & Magadla (2007) – generally are in line with the insights provided by these two bodies of work.

2.6.1 Early work on the 'study orchestrations' of South African students

Meyer and colleagues (Meyer et al., 1990; Meyer, 1991; Meyer et al., 1994; Meyer et al., 1992; Meyer & Parsons, 1989) used inventory instruments to investigate the 'study orchestrations' of students – a term which is a close synonym to 'learning practices'. Their studies included a wide range of South African entrants to tertiary education. Although a new term for learning practices/study behaviours was coined in the study, the categories and item statements in the inventories used were for the most part derived from or informed by inventories available internationally at the time.

In these studies, Meyer and colleagues distinguished between 'desirable orchestrations' and 'undesirable orchestrations' and showed a correlation between the type of orchestration used and the academic performance achieved. Desirable orchestrations were characterized by a pattern of high subscale scores on features considered desirable for effective studying and learning and low subscale scores on undesirable features. Desirable features included deep approaches to learning, reflection, intrinsic motivation, and 'deep' perceptions of the learning context – perceptions of books, assessments, learning environments, and human relationships in learning environments that were considered to facilitate meaning-oriented studying and learning (Meyer et al., 1992). Undesirable features of study orchestrations included surface approaches to learning, extrinsic motivation, the 'learning pathologies' mentioned earlier and perceptions of the learning context associated with a surface approach to learning.

In contrast to desirable orchestrations, undesirable orchestrations were characterized not so much by a pattern of subscale scores that was the opposite of the pattern for desirable orchestrations but by the lack of any clear pattern at all. Meyer described these orchestrations as 'fragmented' or 'dissociated' (Entwistle, Meyer, & Tait, 1991; Meyer et al., 1990; Meyer et al., 1992; Meyer et al., 1990). However, the notion of 'dissociated orchestrations' is somewhat unconvincing even though it has been given attention by researchers outside South Africa (see, for example Entwistle et al., 1991; Prosser & Trigwell, 1999, p. 96).

I would argue that the lack of a statistically discerned pattern of orchestrations is as likely to be the result of shortcomings in the ability of the inventories to gauge students learning practices accurately as to be pointing to some genuinely 'peculiar feature' of their learning practices such as 'dissociated orchestrations'.

Meyer and associates found that, almost invariably, students who passed and were well above average in their academic performance manifested 'desirable orchestrations'. In contrast, students who performed very badly almost always manifested 'undesirable orchestrations' while students whose performance lay between these two groups generally had orchestrations that were intermediate between desirable and undesirable orchestrations. They found further that students who manifested meaning-oriented approaches to learning also tended to display more sophisticated perceptions of learning contexts. In addition, they found a range of orchestrations from desirable to undesirable in each of the student groups they investigated – even in those groups of African students who were expected to manifest only undesirable orchestrations because they had been identified as 'at-risk' because of 'disadvantaged' educational backgrounds.

The orchestrations of most students were found to be remarkably stable through the transition from school through the first year of tertiary study. Particularly noteworthy was the extent to which, for many of the 'at-risk' students, this stability resisted explicit efforts to bring about a shift away from 'undesirable orchestrations'. Case and Gunstone (2002) found a similar effect among third year students. Meyer (1991) suggested that such consistency might be "attributed to enduring motivational influences, habitual ways of approaching learning tasks or stable preferences" (p. 313).

While this body of findings is of general interest to this study it is dated. It relates to the apartheid era when different educational systems were provided to different racial groups. Since 1994, a single, non-racially discriminated system has been in place (Bhorat, 2004) and all school leavers entering tertiary education today have had their schooling under that system. Further, the significance of Meyer's findings is constrained by the research methodology used; student learning was investigated only in terms potentially inaccurate measures of *a priori* categories in a way that was somewhat reductionistic in nature and inevitably overlooked important individual details and nuances.

2.6.2 Learning practices of a group of 'English additional-language' students

Simelane (2007) conducted an interview study that investigated the learning practices of 11 English additional-language African students in their second semester of the chemical and metallurgical engineering programme at Wits. The students in the group were self-selected on the basis of their home language (from the Nguni group) and the experience of having struggled academically in their first semester at university. The students had come from township schools predominantly; only 3 of the 11 had come from suburban or private schools and none from rural schools.

Interviews were conducted in the students' home languages and focused on their practices at school and during their first year at university. The resulting descriptions of their experiences supported the argument that, for

many African students entering engineering education in South Africa, aspects of the learning practices which they develop at school are not appropriate in a tertiary context and constitute an important reason for the academic difficulties they face at university. Simelane found that problematic aspects of their practices included strong teacher dependence, strong reliance on text-based resources, a limited view of the nature of knowledge and learning, reliance on rote learning and pattern recognition, and the perception that problem-solving requires 'knowing the correct procedures' which need to be learned through extensive practice and commitment to memory. This approach to problem solving has also been identified among other South African students and has been classified as an algorithmic or procedural approach to solving problems (Case & Marshall, 2004). The implications of these findings are drawn out in the following summary.

2.7 IMPLICATIONS OF THE LITERATURE REVIEWS

With respect to research related to the learning practices of entrants to South African engineering programmes, both inventory and interview studies have been undertaken. The inventory studies were fairly extensive in nature but almost all are quite dated. The findings from these studies also suffer from the constraints inherent in inventory studies; the fact that the structure of the inventories were derived primarily from non-South African contexts; and the simplification of reducing the analysis of the nature of learning practices to whether or not those practices were deep/desirable in nature or surface/undesirable in nature. The interview studies, though more recent, are quite limited in number and, with one exception, focus primarily on distinguishing between surface and deep approaches to learning. Clearly, further research is indicated if the learning practices of these students are to be better understood.

The findings from the South African studies are consistent with the findings from international studies, as reviewed in section 2.5, although some differences are evident. Two in particular are worth noting. The first is that the problematic aspects of the learning practices of South African students could be clearly related to the nature of their prior schooling to an extent not generally found in international studies. The second difference is that the learning practices of South African school leavers appear to be remarkably stable and resistant to change in the learning contexts which the students encountered in their first year at university even when these were designed to modify those learning practices. It is not clear whether this is a consequence of the nature of the practices themselves, or of the nature of the learning or developmental contexts the students in these studies encountered. What is clear is that the influence of learning practices on how entrants to South African engineering programmes go about learning is strong and that it is important to understand the nature of this influence.

A further conclusion that emerges from the literature review is that the second-order methodology used in SAL research appears to be particularly appropriate for investigating students' learning practices. The next chapter addresses the conceptual framework for this methodology. It also elaborates the working definition of the construct of learning practices and develops a more rigorous conceptual framework for the construct.

CHAPTER 3: THEORETICAL BACKGROUND AND CONCEPTUAL FRAMEWORK

3.1 OVERVIEW OF THE CHAPTER

The previous chapter presented the findings of a review of literature related to the concept of learning practices and research relevant to an understanding of the learning practices of students particularly those entering engineering education in South Africa. This chapter develops the conceptual frameworks needed for an investigation into the learning practices of students. Two conceptual frameworks are developed. Part A of the chapter describes the conceptual framework for the phenomenographic research methodology that has been selected for this study. Part B develops a conceptual framework for the concept of 'learning practices'. This is needed because the concept has not previously been used as a unit of analysis in a study on student learning, as the literature review in Chapter 2 has shown (see section 2.3).

PART A: THE CONCEPTUAL FRAMEWORK BEHIND PHENOMENOGRAPHY

In describing the conceptual framework that undergirds a phenomenographic investigation, I follow Crotty (1998) who advocates a particular format for presenting a conceptual framework: i.e. the ontological and epistemological positions behind an investigation are outlined first followed by an articulation of the research methodology adopted and the specific research methods used. This part of the chapter focuses on the first two aspects while the latter two are addressed in the next chapter.

3.2 THE ONTOLOGICAL UNDERPINNINGS OF PHENOMENOGRAPHY

The most fundamental assumption in phenomenography holds that a person acts in the world on the basis of the way they experience it – the way in which they are aware of that world (Marton & Booth, 1997). "One doesn't see with one's eyes, one sees with the whole fruit of one's previous experience" (Aron Klug quoted in Marton & Booth, 1997, p. 83). People do not live "in an 'objective' world but in an experienced world" (Prosser & Trigwell, 1999, p. 59) – in "an interpreted context" (Biggs, 2001, p. 84). The implication is that any attempt to investigate how people act in the world should focus on their awareness and experience of the world: it should focus on how they experience or are aware of phenomena in the world.

Phenomenography adopts a non-dualistic ontology known as constitutionalism (Prosser & Trigwell, 1999). This maintains that a person's awareness or experience of a phenomenon is constituted as a *relation* between that person and the phenomenon experienced (Marton & Booth, 1997): it is a relation between the experienced and the experiencer and, as such, it does not and cannot exist independently of either (ibid). Therefore, to investigate how people act in the world requires focusing attention on the *relations* between people and the phenomena and situations in the world which they experience.

Phenomenography takes a subjective view of what guides peoples' actions: how the world appears to a person shapes how they act in the world; awareness of the world derives from experiences of the world; experiences of the world are subjective impressions a person acquires as a result of encounters with the world; and a person's consciousness is the sum total of those impressions which are, in principle, *simultaneously present* all of the time (although not all in the same way) and so are always 'present' to influence and shape what the person does in a particular situation. Trigwell and Ashwin (2002) and Prosser and Trigwell (1999) allude to these ideas when they describe how reactions to a current situation are *evoked* on the basis of past experiences.

> "In any act of learning, evoked past experiences, perceptions, approaches to learning and outcomes are simultaneously present in a student's awareness, although in some contexts, one or more of these aspects may be more in the foreground of awareness, while other aspects may be more in the background" (Trigwell & Ashwin, 2002, p. 184).

> "A new learning and teaching situation … evokes certain aspects of … prior experiences, the aspects developed being related to the congruence between the previous situation and the new situation … Different teaching/learning situations evoke different approaches to learning." (Prosser & Trigwell, 1999, p. 167)

3.3 THE EPISTEMOLOGICAL UNDERPINNINGS OF PHENOMENOGRAPHY

The epistemological correlate of the position that a person cannot act in the world independently of their experience of it is that a person cannot know anything about the world independently of their experience of it. As such, a person's knowledge consists of the conceptions of the phenomena which they have experienced.

In phenomenography, the epistemological issue of how a person comes to know something is understood in terms of awareness. A person's conception of a phenomenon is determined by the way in which they are aware of that phenomenon. The question of what it takes to be aware of something is therefore critical to this line of thought. In phenomenography, the answer to that question begins with what Marton and Booth (1997) describe as a figure-ground structure.

> "Our awareness can be characterized in terms of a generalized figure–ground structure: certain phenomena or particular aspects of certain phenomena are figural and make up the core of our [current] awareness, whereas other phenomena or other aspects of phenomena are non-figural and constitute the field surrounding and temporarily concomitant with the core." (Marton & Booth, 1997, p. 100)

From this perspective, awareness relies on the recognition of critical features of a phenomenon or situation and of the structure of these features so that they can be distinguished from the background of everything else. To understand how a person is aware of a phenomenon therefore requires understanding the structure of their awareness. In addition, learning involves a change in a person's awareness and in the structure of their awareness of the relevant phenomena.

The structure of awareness is a conceptual framework that provides an explanation of what it takes for a person to be aware of a phenomenon or of a component of a phenomenon. As depicted in Figure 3.1, the awareness of a phenomenon involves (1) a recognizing of the structural elements of the phenomena that enable it to stand out from everything else around it and (2) an assignment of meaning to that phenomenon as revealed by the structural distinctions which identify it in the person's perception. As indicated in the

diagram, these two aspects of awareness are labeled the structural and referential (meaning) aspects of awareness respectively. The diagram also indicates that recognition of two types of structural features – the 'internal horizon' and the 'external horizon' – are involved in being aware of a phenomenon: the 'internal horizon' (foreground) refers to the structural features that are in focus and characterize the phenomenon and its parts in the person's awareness while the 'external horizon' (background) refers to the features of the background context in which the phenomenon is located (Marton & Booth, 1997).

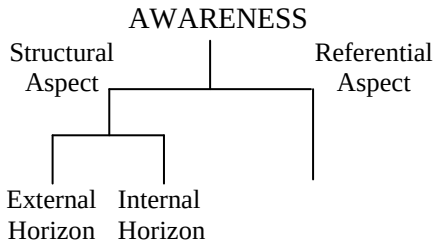


Figure 3.1: The Generic Structure of Awareness
(Adapted from Marton & Booth, 1997, p. 88)

In the phenomenographic literature, the experience of a phenomenon is widely recognized as involving two intertwined aspects – the object of the experience and the processes involved in the experience. These structural distinctions are commonly referred to as the *what* and *how* aspects of the experience (Harris, 2011; Marton & Booth, 1997). With regard to the experience of learning, for example, the relation a person has with learning would involve '*what* is learned' and '*how* it is learned'. What is learned is the direct object or outcome of having learned something. The process of learning – the *how* aspect of learning – is recognized as involving both an *act* and an *intention* as depicted in Figure 3.2. The *act* of learning involves the actual actions or strategies undertaken to learn while the *intention* is the object of the act – what the act intends towards.

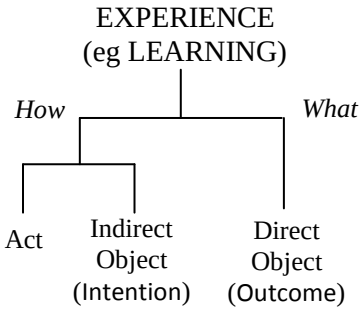


Figure 3.2: The Structure of Experience
(Adapted from Marton & Booth, 1997, p. 85)

3.4 THE PHENOMENOGRAPHIC META-PROJECT

Many criticisms of phenomenography and SAL research findings have at their root an inadequate appreciation of the meta-project behind the phenomenographic research tradition with its emphasis on variation; on the shift in attention from the individual to the collective; and on describing ways of

experiencing something rather than the experiences themselves. Therefore, partly to lay a foundation for addressing these criticisms and partly to fill out this overview of the theoretical foundations of phenomenography, attention is now given to the nature of this meta-project.

From its inception, phenomenography has had a strong pedagogical agenda (Marton et al., 1997; Prosser & Trigwell, 1999; Ramsden, 2003), namely to understand the dynamics of student learning from the students' perspective and to do so in a way that might usefully inform teachers in their efforts to facilitate and improve student learning. What is of particular concern to a teacher is not just how an individual perceives a phenomenon, but the range of ways in which the students in a class perceive that phenomenon (Marton, 1981; Marton & Booth, 1997). Phenomenography therefore sets out to investigate the *possible* different ways of experiencing, conceiving, perceiving or understanding a phenomenon and to understand the implications which the *set of possibilities* have for teaching and learning. Armed with such information, a teacher can gain insight into the kind of learning pathways which students would need to follow if they are to acquire a more sophisticated experience or conception of that phenomenon. The teacher can then develop teaching and learning strategies accordingly (Entwistle, 1997). I use the term 'the phenomenographic shift' to refer to this shift of attention from individual students to groups of students and the shift from investigating how students experience a phenomenon to investigating how a phenomenon is or can be experienced by students.

In phenomenography, the assumption is made (and is amply demonstrated empirically) that, because people are different, the world is constituted in the awareness of different individuals in different ways (Kroksmark, 1987 cited in Booth 1992). This means that there are different ways in which a phenomenon can be conceived or experienced – there is variation. "Individuals are seen as the bearers of different ways of experiencing a phenomenon, and as the bearers of fragments of different ways of experiencing that phenomenon" (Marton & Booth, 1997, p. 114). Given the position that people act in the world according to how they experience it, it follows that in order to gain insight into the different ways people behave in the world it is necessary to understand as clearly as possible the variation in the ways that a phenomenon can be experienced by those people. The meta-project of phenomenography is to gain insights of this kind as a means of addressing the pedagogical agenda just described.

In order to maximize the potential pedagogical impact of phenomenographic research, a principle of parsimony guides the methodology used: the focus is on discerning only the essential qualitative differences that characterize the variation in the ways the people conceive or experience the relevant phenomena. Put another way, the researcher attempts to cut through the idiosyncrasies of individuals so that what is crucially different about the different ways in which the phenomenon is conceived by people collectively becomes evident (Marton & Booth, 1997). The rationale behind this strategy is that, to be pedagogically effective, the research outcomes need to be amenable to practical implementation and this is difficult when the results are not parsimonious. Biggs (2001) highlights this point when discussing

problems associated with trying to utilize a multitude of subscale information derived from inventory studies. The following quotation summarizes these points very clearly.

> "Phenomenography is focused on the ways of experiencing different phenomena, ways of seeing them, knowing about them, and having skills related to them. The aim is, however, not to find the singular essence [as in a phenomenological study], but the variation and the architecture of this variation in terms of the different aspects that define the phenomena. (p. 117) … The description we reach is a description of variation, a description on the collective level, and in that sense individual voices are not heard. Moreover, it is a stripped down description in which the structure and essential meaning of the differing ways of experiencing the phenomenon are retained, while the specific flavours, scents, and the colours of the worlds of individuals have been abandoned." (Marton & Booth, 1997, p. 114)

3.5 THE UNIT OF ANALYSIS IN PHENOMENOGRAPHY

While it is very clear from the literature that the unit of analysis in phenomenographic research is the relation between a person and a phenomenon, it is more common to describe it in terms of either 'conceptions' (Harris, 2011; Svensson, 1997) or 'ways of experiencing a phenomenon' (Marton & Booth, 1997). Marton and Booth also cite alternative phrases: 'ways of comprehending'; 'conceptualizations'; and 'ways of understanding'. The different terminology derives from the different research contexts and interests that dictate the perspective taken on the relation between people and the phenomenon in question.

3.6 CRITICISMS OF THE SAL TRADITION AND RESEARCH FINDINGS

As the findings of SAL research have become more widely used, they have fallen prey to a variety of criticisms. These could not be addressed adequately before this point because many of the criticisms derive from a failure to properly appreciate the phenomenographic conceptual framework on which SAL research is based. The criticisms fall into five categories: the association between SAL research and inventory studies; reductionism; reification; conceptual slippage; and internal inconsistencies.

Inventories and SAL research

Many studies into student approaches to learning have involved the use of inventory instruments (see, for examples, the seminal studies by Biggs, 1987; Entwistle, 2003; Entwistle & Ramsden, 1983; Prosser & Trigwell, 1999; Vermunt & Vermetten, 2004). As explained in Chapter 2 (section 2.4.2), inventories are generally used to gather data from groups of people in regard to their reactions to set questions – questions derived from preconceived positions or *a priori* models. In effect, when SAL perspectives are 'operationalized' in the form of inventories, what is happening is that a model of student learning derived from SAL research is used to develop the categories and statements used in the inventory instrument; the second order perspective of SAL is lost and, as Case and Marshall (2009) indicate, the inventory study is not in fact an SAL investigation. Many of the criticisms of SAL research derive from this confusion and, in effect, are criticisms of the reductionism and reification that is associated with the use of inventories rather than the use of the SAL research methodology itself.

Reductionism

The criticism here is a complaint about the reductionism that seems to be inherent in SAL research or at least to have developed as a result of the popularization of SAL findings – in particular deep and surface

approaches to learning – so that many of the complexities associated with student learning are overlooked (Gamache, 2002; Haggis, 2003). Haggis (2003) expresses the concern as follows.

> "This level of generalisation makes the [SAL] model [of student learning] initially attractive, but, as with all general models, questions can be raised about whether, and how, such generality can provide support for practitioners, when they try to actually apply such ideas to the messy and complex realities of their individual teaching and learning situations" (p. 95).

Clearly this criticism targets the limitations of the model derived from SAL research but it fails to recognize both the phenomenographic meta-strategy behind SAL research and the way in which aspects other than surface-deep approaches to learning have been investigated. The specific intent in SAL research is to see through the idiosyncrasies of individuals in order to discover what is of critical importance for a teacher to know about the group of students facing him/her. Haggis fails to appreciate this collective focus of SAL research and seems also to have overlooked the impressive fruit of that collective focus – something of the order of a revolution in higher education, sometimes referred to as the student-centered teaching movement or the student-learning-centered movement (Evans & Kozhevnikova, 2011; McCune & Entwistle, 2011; Trigwell, 2010). With regard to aspects other than approach to learning which SAL research has investigated, the review in Chapter 2 discussed the nature of understanding, knowledge objects, 'ways of thinking and practicing', and different strategies for attaining a deep understanding of a discipline.

Reification

Here the criticism points to a typical problem that arises with any successful model developed from research: key features of the model tend to be treated "as describing a kind of 'truth' about [in this case] how students learn" (Haggis, 2003, p. 91). Further, with a little conceptual slippage, the key features become reified as for example "'deep approaches to learning' become 'deep learning', and … ultimately metamorphose into 'deep learners'" (Marshall & Case, 2005, p. 258). The criticism here is appropriate although, as will be shown next, ambiguities in the SAL model itself make it particularly vulnerable to this problem.

Conceptual slippage and inconsistencies

An area of inconsistency in SAL research is confusion about the extent to which the tendency to adopt a surface or deep approach is the result of trait-like qualities or is contextually determined. This ambiguity is evident in an earlier quotation from Entwistle.

> The ways students approach their learning "are affected by their prior educational and personal histories, which produce habitual patterns of study. However, the content and context of a [learning] task evoke strategies which are specific to that particular situation. Both consistency, up to a point, and a certain variability, have thus to be incorporated into descriptions of student learning." (Entwistle, 1998, p. 43)

In addition, Biggs (2001) draws attention to the ambiguity inherent in the term 'approach to learning' as used in the SAL literature. "It can refer to two things: (a) the *processes* adopted during learning [the activities performed while learning] … and (b) the *predispositions* to adopt particular processes" (p. 84). He advocates using 'orientations' for the latter and 'strategies' for the former and clearly has in mind that settled orientations result from the honing of past experience. However, in this regard, he is advocating a

trait-like attribute and overlooks the way in which context can influence the *perceptions* of a student as they encounter and become engaged in a learning task.

Summary

Some of the criticisms leveled at the SAL tradition derive from misconstruing its conceptual foundations and research agenda, some are complaints derived from the consequences of the way SAL findings have been popularized, and some point out legitimate inconsistencies such as the ambiguity between approach and orientation just mentioned. This is one of the issues that is resolved in the development of a conceptual framework for 'learning practices' that is presented next.

PART B: A CONCEPTUAL FRAMEWORK FOR THE CONSTRUCT OF 'LEARNING PRACTICES'

What is meant by the term 'learning practices' has a major bearing on the scope of this study; it demarcates what lies within the realm of the study and what does not. In section 2.3, it was noted that the term has not been used in a specific technical way in the literature on student learning. Consequently, a rather general working definition was initially adopted for the term; "how an individual goes about and engages in studying and learning in the context of being a student at an institution of formal education such as a school, technikon, college or university" (see section 1.1). This was later elaborated to "the web of processes, strategies, dispositions, and orientations developed from past experience which together influence how a student engages in studying and learning activities". In the latter definition, 'learning practices' functions as a kind of generic 'basket term' for a variety of attributes and processes. However, such usage fails to convey properly the sense of a holistic, integrated complex of attributes, dispositions and ways of knowing and doing that a person brings to bear when they act in the world. The association between 'orientations to learning' and 'learning practices' noted in the review of SAL literature (section 2.5.4) captures some of this sense.

The above observations suggest that, at the outset of this study, it is necessary to develop a more rigorous conceptual framework for the construct 'learning practices'. This need becomes even more apparent when attention is drawn to the wide range of meanings of 'practice' and 'practices' found in dictionary definitions and in more technical usage such as in sociology (for example, Bourdieu, 1977), in philosophy (for example, Schatzki, Cetina, & von Savigny, 2001), in social anthropology and learning-theory (for example, Lave & Wenger, 1991), and in engineering (see Sheppard, Colby, Macatangay, & Sullivan, 2006). Accordingly, this part of the chapter is devoted to developing a formal conceptual framework for the construct 'learning practices' that is compatible with the conceptual framework of phenomenography. Insights are first drawn from an eclectic mix of perspectives on practice and learning after which the conceptual framework for 'learning practices' is developed.

3.7 'PRACTICE', 'A PRACTICE' AND 'PRACTICES'

The following two definitions derive from two practice theorists.

> A practice is "a routinized type of behaviour which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, 'things' and their use, and a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge." (Reckwitz, 2002, p. 250)
>
> Practice is "a complex set of techniques (for diagnosis; for problem-solving; … for planning; for assessment; for the administration, organisation and delivery of service, etc.) that can be considered, changed, deployed, taught, learned and transferred independently of the contingent and temporal circumstances of actual situated practice." (Schwandt, 2005, p. 316)

The first definition emphasizes the complex, multi-dimensional nature of 'a practice'. The second takes the idea further to add that an individual can exercise a number of different 'practices' and that these different 'practices' can operate together as a single meta-practice or 'practice'. Sometimes in the thesis, when it seems necessary to stress the latter idea, I will use the phrase 'practice (singular)'.

From the above definitions and from reference to the Oxford and Webster's dictionaries, it becomes apparent that the terms 'practice' and 'practices' embody the following themes and features.

- A*ctivity*: Practices involve doing things or the capacity to do things.
- *Regularity*: The nature of practice activity is to some degree predictable and has recognizable structure.
- C*omplexity*: Practices involve a complex range of elements and components and may involve a wide range of types of activity – from simple customs or habits (for instance, 'he had developed the practice of rising early'), through more complex routines (such as the practice of mind mapping), to 'established ways of engaging effectively in real-world complexities', to the specialized and complex activity of an expert.
- *Competency*: To some degree a person's competency derives from the quality of their practices. Here competency is taken to mean "*the knowledge, skills, abilities, attitudes, and other characteristics that enable a person to perform skillfully (i.e. to make sound decisions and take effective action) in complex and uncertain situations such as professional work, civic engagement, and personal life*" (Passow, 2007, p. 1; also cited in Woollacott, 2009, p. 261).
- *Prior learning*. Practice activity derives from and is shaped by prior experience of some kind.
- *Automaticity*: To a degree, practice is associated with habits or routinized ways of doing things. In other words, practices have trait-like qualities. The review of SAL literature in Chapter 2 noted some uncertainty about the role of trait-like characteristics in student learning. Consequently, automaticity is an issue that has some relevance to the concept of 'learning practices' and the next section discusses the issue in more detail.

3.8 AUTOMATICITY AND ROUTINIZED BEHAVIOUR

Automaticity – or routinized, 'automaticized', or 'automatized' behaviour – is a well-known and much studied phenomenon in psychology. Sternberg defines it as "a phenomenon in which experts have so thoroughly mastered the procedure and heuristics in their area of expertise that the manipulation of these operations is virtually automatic and requires little conscious effort for implementation." He goes on to say that "automaticity is not limited to experts; many common tasks, such as driving a car, become increasingly

automatic with practice." (Sternberg, 1995, p. 333). Automaticity seems to be operative with virtually any kind of behaviour that is or has been undertaken repeatedly or regularly, "behaviour that has been learned and becomes so familiar that it no longer needs to be directly attended to while it is carried out" (Tyson, 1987, p. 133). Helie and Cousineau (2011) argue that "most of our everyday activities appear effortless and automatic. … This ease in navigating the world is the result of [prior experience of] thousands of interactions with similar objects in similar contexts, which routinize most everyday activities" (p. 3). From the basis of these observations and the fact that 'practice/s' are developed as a result of prior experience, it is clear that automaticity will be a characteristic of some, possibly most, of the processes which make up practices.

Further insight on the nature of practices, automaticity and what is happening as a practice develops can be gleaned from studies on the development of expertise – the process of progressing from being a novice to becoming an expert. The way in which a practice develops – that is, the process by which behaviour becomes routinized – has been studied primarily in the contexts of the acquisition of language (Gobet, 2005); the intentional acquisition of a skill such as in learning to drive a car and the development of expertise through the accumulation of experience (Dreyfus & Dreyfus, 2005); and the implicit kind of learning which occurs through repeated practice as, for example, in the intentional training by elite athletes to attain and maintain excellence of performance (Ericsson & Charness, 1994).

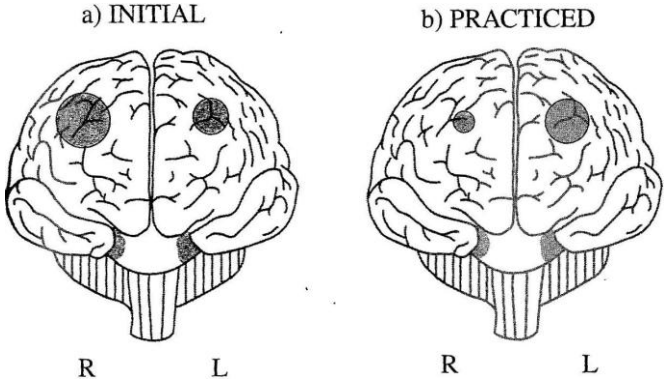
Various models have been formulated to describe and explain how expertise develops. Chase and Simon (1973) developed 'chunking theory' which posits that expertise develops as a kind of advanced pattern recognition ability, a developed ability to discriminate between a large number of patterns of associations or 'chunks' of relevant factors. This perspective has been further refined as Template Theory (Gobet, 2005; Gobet & Simon, 1996). Dreyfus and Dreyfus (2005), in their phenomenology of expertise, identified 5 stages in the progression from novice to expert: novice, advanced beginner, competent, proficient, expert. Pena (2010) summarizes this progression succinctly as "a gradual transition from a rigid adherence to taught rules and procedures through to a largely intuitive operation that relies on deep, implicit [tacit] knowledge" (p. 1). According to the Dreyfus model, the shift from reliance on rules to intuition involves first the development of intuitive *perceptions* and thereafter the development of intuitive *responses* to situations as they are perceived. The emphasis on the role of intuition in expertise is one of the hallmarks of this model and is in accord with the earlier remarks about the nature of automatized behaviour. As Dreyfus and Dreyfus state, "expertise is based on the making of immediate, unreflective situational responses; intuitive judgement is the hallmark of expertise. Deliberation is certainly used by experts, if time permits, but it is done for the purpose of improving intuition, not replacing it" (Dreyfus & Dreyfus, 2005, p. 779).

Taking the development of expertise to be a particular instance of the development of practice, I argue that intuition, tacit knowledge and intuitive processing are significant features of practices. This argument is a major reason why this study has not adopted the SRL perspective on student learning; that perspective

overlooks the domain of the tacit because self-regulation of learning is seen as involving proactive rather than intuitive processes. In contrast, the SAL perspective, which holds that an approach to learning is *evoked* in the moment, is much more in line with what has been said about the automaticized dimension of practices.

With regard to the extent to which practices are automatic, quasi-automatic or non-automatic in nature, considerable differences of opinion are evident in the literature. Dreyfus' contention that expertise is characterized by perceptual intuition and intuitive responses has been criticized and sometimes refuted. For example, Feigenbaum and McCorduck hold the opposite view and state that "almost all the thinking that professionals do is done by reasoning" (Feigenbaum & McCorduck, 1983, p. 18, cited in Dreyfus and Dreyfus 2005, p. 780). Many researchers take an intermediate position holding that there is an active interplay between intuitive (automatic) processing and explicit (non-automatic) processing – i.e. reasoning (Ark, Brooks, & Eva, 2006; Kulatunga-Moruzi, Brooks, & Norman, 2001; Norman & Rumelhart, 1983; Pena, 2010).

Recent developments in cognitive neuroscience are very illuminating on this issue to the extent that a brief diversion into this domain of research is warranted. There is very strong evidence that the brain processes novel and familiar tasks differently (see for example the review by Goldberg, 2001). Figure 3.3 below summarizes evidence to the effect that "a novel task activates predominantly the right pre-fontal cortex [and,] as the task becomes familiar, the overall level of activation drops and shifts from the right to the left pre-fontal regions" (Goldberg, 2001, p. 71). Much evidence of this kind supports the position that intuitive (automatic) and explicit (non-automatic) types of cognitive processing occur in different parts of the brain; that they occur together when a situation is unfamiliar; that as familiarity grows over time, such as when a practice develops, explicit cognitive processing of that task declines considerably and intuitive processing increases; and that overall control of the task shifts from the right to the left side of the brain. In addition, if novel elements are introduced to an otherwise familiar task, the relative level of explicit cognitive processing increases.



Key: The circled grey areas indicate pre-fontal regions of the brain activated by engagement with a task (a) when the task was new and (b) when the task had been practiced.
R, L indicate 'right' and 'left' respectively.

Figure 3.3: Different brain activation patterns when performing novel and practiced tasks
(Goldberg, 2001, p. 71)

While the discussion in this section has considered perspectives different from the one selected for this study, it has served the useful purposes of deepening the understanding of the nature of practices and

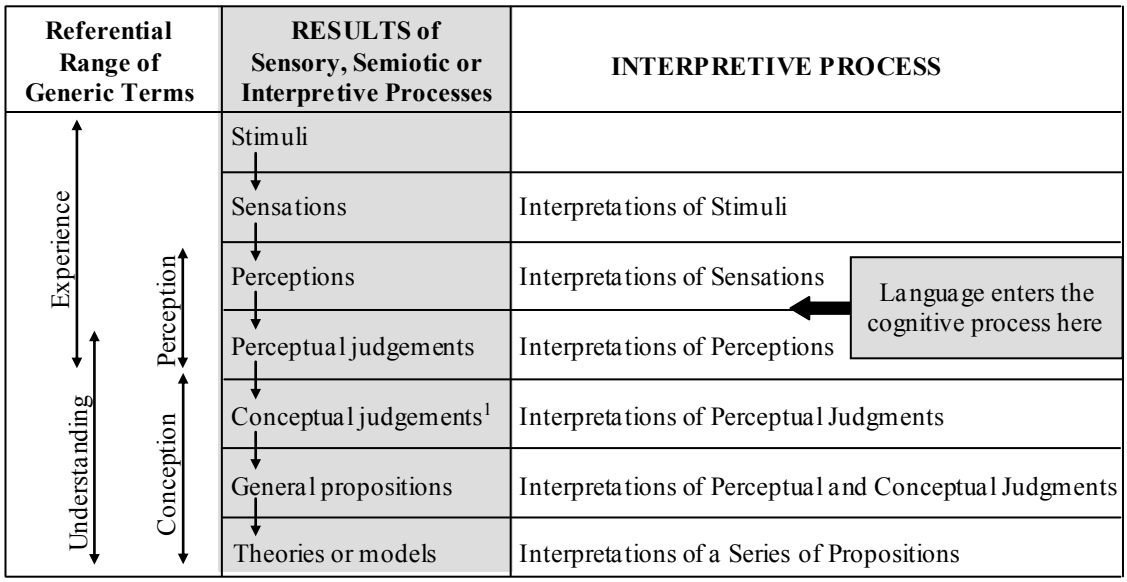
thereby providing insights that endorse, enrich and clarify the SAL perspective on learning. The argument that has been developed up to this point can be summarized as follows.

- Practices are the result of repeated or regular engagements in a given type of activity in a given context that have resulted in the development and accumulation of a body of tacit knowledge and intuitive processing skills that enable that activity to be performed relatively automatically, that is without much conscious attention.
- That body of knowledge and skills appears to consist of a complex and extensive network of patterns of associations, perceptual intuitions and responsive intuitions that the person's experience of multiple engagements in the activity in the past has developed.
- Practice is a repertoire of practices that enables further engagements in a particular type of activity to be performed relatively effortlessly and with a degree of execution efficiency that is derived from and depends on the quality of the tacit knowledge and intuitive processing skills that has been built up.
- Engagements in a particular activity in the moment involve a mix of both explicit processing (reasoning) and implicit/intuitive processing the nature of which depends on the perceived novelty of the activity.

The last two points in the above summary have to do with how practices influence activity in the moment. They draw attention to the role of perceptions in shaping how a person responds to that context. The next section discusses this aspect of practice in more detail and develops a perspective on practice that is more dynamic in nature than in the perspectives discussed so far.

3.9 PRACTICES AND PERCEPTIONS OF CONTEXT

Dahlin, in his work to "enrich the theoretical horizons of phenomenography" (the title of his paper, Dahlin, 2007), drew on Peirce's semiotic model of perception and cognition (Peirce, 1867) which is depicted in Figure 3.4. That model argues that cognition progresses by means of successive interpretations of stimuli, sensations, perceptions, perceptual and conceptual judgments (conceptions), propositions and theories. So for example, a perceptual judgment is an interpretation of a perception, which is in turn an interpretation of a sensation, which is an interpretation of stimuli experienced. (Note that, in this scheme, the distinction between perceptions and perceptual judgments has to do with the introduction of language and the assignment of meaning to (sensual) perceptions. More usually, the two are combined under the same label 'perceptions'.) Theories and models, the most complex aspects of cognition, are, according to Dahlin and Peirce, the culmination of successively more complex interpretations from stimuli through to propositions. This suggests that at different points in the development of the relation between a person and a phenomenon the relation will be different. In other words, a person's relation with a phenomenon has a temporal dimension. It seems obvious that the lower-level, perceptual outcomes (stimuli, sensations, perceptions – levels 1 to 4 respectively) happen in the moment of encountering the phenomenon while the higher-order outcomes (concepts, propositions and theories – levels 5, 6 and 7) take more time to develop and are more amenable to being shaped by reflection.



[1] Alternatively 'Particular Propositions' or Concepts/Conceptions. Dahlin is unclear on this point.

Figure 3.4: Peirce's Semiotic Model of Cognition
(Compiled from Peirce, 1867, as cited in Dahlin 2007)

Although Peirce's ideas relate to semiotics and cognition, Dahlin has interpreted them from a phenomenographic perspective and so it is helpful to outline the points he has made. I go a little further than he does on some points in order to relate the model to practices, something which Dahlin does not do.

First, Dahlin distinguishes between experience/perceptions and understanding/conceptions on the basis that they implicitly refer to different stages in the history of a person's relation with a phenomenon. A person's 'experience' of a phenomenon relates to the 'early', perceptual stages of an encounter with that phenomenon (stimuli, sensations, perceptions and perceptual judgments); it consists essentially of the perceptions 'in the moment' which a person forms as a result of an encounter with the phenomenon. In contrast, a person's 'understandings' relate more to the subsequent interpretations of that experience (the interpretation of perceptual and conceptual judgments, propositions and the development of theories). Dahlin considers 'understandings' and 'conceptions' to have essentially the same meaning. Figure 3.4 maps out these distinctions.

The depiction of cognition presented in Figure 3.4 is as a one way development of cognitive outcomes from lower-level to higher-level outcomes – from (1) stimuli to (7) theories/models. The depiction is somewhat static which belies the dynamic nature of the processes involved. Specifically, the interpretive processes portrayed in the diagram rely on the current status of a person's cognitions so that higher-level cognitive outcomes mediate the development of lower-level interpretations in a direction opposite to that indicated in the diagram: they act as "interpretants" in the interpretation processes (Dahlin, 2007, p. 331). This is in accord with the constructivist ideas of Millar and Driver (1987) who suggest that a person's conceptions act as a kind of filter that shapes what they see in a situation and how they interpret what they see.

An additional aspect which the diagram does not draw attention to is the effect of multiple encounters with a phenomenon. Apart from the obvious impact of these on an individual's memory, repeated exposure to a phenomenon would be expected to lead to a process of consolidation and refinement of relevant higher-level conceptions of that phenomenon. The combined effect of these observations, I would argue, is that current awareness of the phenomenon is influenced by prior experience of that phenomenon and also a person's awareness of that phenomenon is dynamically refined and modified on each occasion when it is encountered and experienced: the past influences the present and the present the past. Although Dahlin's model does not give attention to how tacit knowledge and intuitive processing skills might develop, it is an easy extrapolation to suggest that they develop in the same way as conceptions and theories do and are in fact an integral part of those conceptions and theories. The net effect of the various dynamics that have been described is that a phenomenon is perceived in a different way every time it is encountered – or at least in principle it is; a person's conception of that phenomenon – their relation with it – shifts and develops every time they encounter and experience it.

The insights that have emerged from Dahlin's interpretation of Peirce's model have several implications for an understanding of practices. First, they imply that a person's practices consist of the conceptions, tacit knowledge, and intuitive processing that develop from their prior encounters with the phenomenon in question and which influence how the person perceives the phenomenon and responds to it in further encounters with that phenomenon. Second, practices influence both how a phenomenon is perceived as well as how it is responded to. Obviously, the particularities of the context will also influence how the phenomenon is perceived. Third, practices are dynamic in nature both influencing and being influenced by every experience of encountering the phenomenon in question. It is interesting to note that this point resonates with one which Prosser and Trigwell (1999) make in regard to their version of the 3P model (see Figure 2.1 on page 21); they suggest that the influences intimated by the lines in that figure should be considered to act in both directions.

3.10 PRACTICES, ORIENTATIONS AND LEARNING PRACTICES

The focus of this part of the chapter has been to develop a conceptual framework for the construct 'learning practices'. To do this, attention was focused first on the meaning of 'practice' and 'practices' and thereafter on various aspects of their nature. The various points that have emerged in this regard are now drawn together into the following formal definition.

> *A practice (singular) consists of a repertoire of practices each of which consists of a web of conceptions (including personally developed theories, propositions, and perceptual and conceptual judgments) that are tightly associated with a body of tacit knowledge and intuitive and explicit processing skills that have together been moulded and refined by past experience into ways of perceiving and responding to familiar situations – ways that are coherent and executionally efficient in that a minimum of conscious attention is required for their execution.*

One point which this definition does not highlight is that a person's practices in regard to a particular phenomenon constitute how that person relates to that phenomenon, i.e. how they are oriented towards it. Such orientations have trait-like qualities because they derive from conceptions, tacit knowledge and skills that have been consolidated and refined and have become part of the 'fabric' of the person's wider network of knowledge and skills. In this regard, practices and orientations are synonymous, a conclusion that was reached previously in the review of SAL literature (see section 2.5.5).

Another point which the definition does not highlight is that, in principle, these practices/orientations embody all the various internal characteristics – conceptions, knowledge and skills – which have in the past influenced how the person has related to that phenomenon and, consequently, that influence how they relate to the phenomenon in a current encounter with it. This point resonates with Ramsden's version of the 3P model of student learning (Figure 2.2, page 21) which explicitly indicates student characteristics, and prior experience (including experiences of learning contexts) as being the factors shaping a student's orientations to learning which in turn influence their perceptions of learning contexts.

A further point not mentioned in the definition, but one that is implicit, is that practices/orientations are context dependent because they derive from experiences that had specific contexts. Again this resonates with the double influence of context which is implied in Ramsden's version of the 3P model: i.e. learning contexts influence student learning both directly and indirectly. How a learning situation is experienced in the moment is influenced directly by the particularities of that situation. However, more indirectly, the contexts of prior experiences have influenced the development of a student's learning practices and these in turn influence how that student perceives and responds to learning situations in the present.

The various observations that have been made in this section are now drawn together into the definition of learning practices given below.

> *Learning practices are practices, as defined above, associated with the activity of learning. They are orientations to act in learning situations in certain ways and with certain intentions that people have developed as a result of past experience.*

The two conceptual frameworks that have been developed in this chapter – the first relating to phenomenography and the second to practices and learning practices – provide the theoretical foundation for the discussion on methodology and research design which follows in the next chapter.

CHAPTER 4: METHODOLOGY, RESEARCH DESIGN AND EXECUTION

A phenomenographic research approach has been selected for this study on students' learning practices. Three primary reasons for this choice emerged from the reviews of literature in the previous two chapters. First, phenomenography is a research paradigm that has proved to be particularly productive for investigating student learning and for informing a range of initiatives for improving the quality of education (Entwistle, 2003; Marton et al., 1997; Prosser & Trigwell, 1999). Second, learning practices are complex and phenomenography is "particularly appropriate for engaging with complex, controversial or deeply held issues and viewpoints" (Cherry, 2005, p. 62). Thirdly, as the literature review in Chapter 2 has shown, it is an approach that has not been used extensively in the South African research effort to investigate issues associated with the problems of high attrition and academic underperformance of South African university entrants and, apparently, not at all in regard to understanding their learning practices as a whole.

The previous chapter developed the conceptual framework for the study. This chapter reviews phenomenographic methodology and then describes the specific methods employed in the study and the implementational details of the investigation that has been undertaken.

4.1 METHODOLOGY

The way a phenomenographic study proceeds is to select a sample from the target group that, as far as possible, embodies the variation being investigated. Data is collected from the sample in the form of meaningful descriptions or observations about how the individuals perceive, experience, or relate to the phenomenon in question. This data, or relevant extracts drawn from it, constitutes the 'pool of meaning' (Marton, 1981) – the collection of expressions of conceptions and experiences – that have been found in the target population with regard to the phenomena of interest. The descriptions and observations are then examined carefully to discover what is qualitatively different about them so that distinct categories can be identified. Each category is labelled; the labels are referred to as 'categories of variation' or 'categories of description'. The way in which the categories are similar and different and how they inter-relate constitutes what is most important about how the subjects as a group perceive or experience the phenomenon in question. The structure of similarities, differences and associations constitutes the 'structure of awareness' that is characteristic of that group and, together with the categories of description, constitutes the 'outcome space' of the study. More detail on each of the stages in a phenomenographic study follows.

4.1.1 Sample selection

The principle guiding both sample selection and subsequent data collection is that both must facilitate a full exploration of the nature of the variation being investigated (Booth, 1992). Green (2005) recommends 'maximum variation sampling' – an approach that has the objective of maximizing the variation in ways of seeing, conceptualizing, or experiencing the phenomenon that are manifested by members of the sample.

In common with maximum variation sampling methods used in other qualitative research approaches (Cohen et al., 2007), selection criteria must be established that embody the range of dimensions – such as gender, age, background etc. – that are likely to influence the sample's perspectives on the subject being researched.

4.1.2 Data collection

The type of data collected for a phenomenographic investigation can take various forms – recorded interviews, observations, video recordings of the subjects, or material written by the subjects (Booth, 1992; Bowden & Walsh, 2000). The former is the most common and the only one that will be considered here.

Phenomenographic interviews are semi-structured (Green, 2005). A short list of questions is developed that together probe a range of perspectives on the relations between the subjects and the phenomenon. These questions provide the primary structure for the interview and help the interviewer to ensure that the perspectives embodied in the questions are addressed in the interview (Booth, 1992). They should be developed not only through careful forethought but also by testing in pilot interviews (Green, 2005). The interviewer must, however, be sensitive to the need to deviate from the questions in order to follow unexpected shifts of focus during the interview. Such deviations should be pursued with the interviewee if they are relevant and productive in that they lead to new or deeper insights into the nature of the subject's relation with the phenomenon being explored (Booth, 1992). A useful guide in making such decisions (and in the interview as a whole) is to seek the subjective understandings of the interviewee rather than "opinions that have been reached as a result of the interview situation" (Kroksmark, 1987 cited in Booth, 1992). To facilitate a focus on subjective understandings rather than 'opinions', the interviews should begin with a careful explanation of its purpose and nature (Booth, 1992). The interview is recorded and transcribed and the transcriptions constitute the data for the phenomenographic study.

4.1.3 Data analysis

Explanations of the phenomenographic method for analysing data emphasize its heuristic, creative, iterative and immersive nature (Akerlind, 2005a; Berglund, 2005; Booth, 1992; Marton, 1981). The literature is unanimous in stating that a precise algorithm cannot be described and followed. The objective of the analysis, however, is clear – to tease out or discover from the data a parsimonious set of categories that describe the essential differences in the ways the subjects relate to, perceive or experience the phenomenon that is the focus of the study. Different researchers will go about this task differently (Akerlind, 2005b) but there are common elements.

The first common element is thorough immersion in the material. The data, frequently interview transcripts, are read and examined repeatedly and in different ways and from this a deep familiarity with that data grows. Phenomenographers talk about the data as a 'pool of meaning' that needs to be explored and understood deeply (Akerlind, 2005b).

The second common element is that appropriate ways must be developed for making the data manageable and for identifying what is significant about how the subjects conceive and relate to the phenomenon

(Akerlind, 2005a, 2005b). Transcripts or extracts from them may be classified into groups, summaries may be written, and notes made. From the combination of deep immersion and exploration of the data, proto-categories of the different conceptions of the phenomenon begin to emerge (Booth, 1992).

The third common element of a phenomenographic analysis is its iterative nature (Bowden & Walsh, 2000). Every stage of the analysis may be repeated several times and from different perspectives. Some iterations promote deeper familiarity with the data, some refine emerging understandings and classifications, while others constitute re-starts that deliberately look at the material from a different perspective. Frequently, more than one researcher is involved in the analysis and further iterations are spawned by discussions and comparisons of findings. (The single researcher context of a PhD study constrains this aspect of the methodology to some extent although the two supervisors of the project constituted a reference group for discussing aspects of the analysis as it unfolded.) The process is clearly creative and non-algorithmic.

A further common element is the sense of saturation or theoretical exhaustion (Akerlind, 2005a, 2005b) that grows in the latter stages of the analysis as divergences are explored and the proto-categories are refined, coalescence, and, eventually, harden to a final state. Once the categories have been decided upon, they are labelled and constitute the 'categories of variation' that define the different ways in which the subjects relate to the phenomenon in question. The labels are important because they must convey as precisely as possible the essence of what distinguishes one category from another.

The final stage in a phenomenographic study is to establish the structure of awareness that has been found to characterize the target population (Akerlind, 2005b; Bowden, 2005; Cope, 2000; Marton & Booth, 1997). This involves an analysis of the categories of variation that focuses on the dimensions of variation that distinguish categories one from another – what is similar, different, and what is critical in going from one category to another. In such an analysis, attention is given to both the internal and external horizon and to the structural and referential dimensions of awareness described in the previous chapter, and to the way in which, for example, a less sophisticated awareness is related to, and could possibly grow into, a more sophisticated awareness.

4.1.4 Rigour and trustworthiness

A crucial aspect of any research study is the issue of rigour and the principles that are followed to ensure that research findings are trustworthy. Rigour is conceptualized differently in objectivist and subjectivist research paradigms. In objectivist research, the primary criteria are validity, reliability, and generalizability (Cohen et al., 2007; Collier-Reed et al., 2009) while the criteria in subjectivist research are somewhat contentious (Booth, 1992). Collier-Reed et al. (2009) suggest that a consensus has developed around the criteria of 'credibility', 'transferability', and 'dependability' as an appropriate basis for assessing the 'trustworthiness' of interpretive research and, more specifically, for judging whether "the outcome of phenomenographic research can be taken seriously" (p. 346).

With regard to *credibility,* the concern is with the "correspondence between the way the respondents actually perceive social constructs and the way the researcher portrays their viewpoints" (Mertens & McLaughlin, 2004, p. 106, cited in Collier-Reed et al., 2009). In particular, three aspects require attention: content-related credibility, credibility of method, and communicative credibility.

To ensure *content-related credibility* the researcher must be deeply familiar with the subject matter. Without such familiarity they are likely to miss important nuances both at the interview and analysis stage of the study. With regard to *credibility of method,* it is important that the way the investigation has been conducted follows the established principles of the phenomenographic methodology in regard to the selection of the student sample, the design and execution of the interview, and in the analysis and reporting of the results. With regard to *communicative credibility* the appropriateness of the way in which the findings are reported is the issue. Reporting should have an 'internal credibility' in that the language and discourse used in presenting the findings must be that of other actors in the field of study – in this case teachers and researchers involved with first year engineering students. The discourse used in presenting the findings should also be understandable by other phenomenographers – it should have an external credibility in the way it is reported.

With regard to *dependability* the question is the 'consistency' of research findings and the quality and appropriateness of the research process used to obtain those findings (Collier-Reed et al., 2009). Dependability is equivalent to the criterion of reliability and repeatability in positivist research. Some have argued that credible research by definition is dependable but others suggest that dependability should be addressed as an issue on its own irrespective of any demonstration of credibility (Lincoln & Guba, 1985). Collier-Reed et al. (2009) suggest that in the case of phenomenographic research, dependability checks should be included at key points in the research process – specifically in the interview, transcription and data analysis phases. In the interview phase, dependability rests on grounding the interview in the student's experience and being careful to avoid rhetorical questions or questions that put words in a student's mouth. In this regard, careful attention should be given during the interview and, prior to the interview, the questioning strategy should be checked accordingly. Conducting pilot interviews is a further method for facilitating the dependability of the data collection process (Green, 2005). In the transcription and data analysis phases, dependability can be checked by implementing double processes. Transcriptions should be checked by a person other than the transcriber. In team-based research, the development of the categories of description can be done by two or more researchers either in parallel or in some appropriate sequential checking strategy (Collier-Reed et al., 2009). In a single-researcher mode, such as is the case in this study, the dependability of the data analysis phases rests on the 'credibility of method' as described earlier and, ideally, on appropriate consultation with experienced phenomenographers at critical points in the investigation.

With regard to *transferability* the issue has to do with the 'applicability' of the research findings to a different context and the requirement that the reader of the research output is able to find sufficient

explanation of the study context to assess the extent to which it is similar to the reader's context (ibid). As with the criterion of dependability, it could be argued that research that has communicative credibility as described earlier will also have transferability.

4.2 RESEARCH DESIGN

As indicated in the prologue, this study was initiated – along with others – in the context of a broader research and development effort. Full ethical clearance for the broader effort was obtained and adhered to (clearance letter H080101, University of the Witwatersrand). The data collection phase of this study was completed on the basis of this clearance and according to the design set out below.

The context of the study was the first year engineering programme in the School of Chemical and Metallurgical Engineering at Wits. The target population was all first-time first year students in the intake: repeat students and those who had had some form of post-secondary educational experience were excluded. The reason for this is that the study focuses on the transition between school and university and the learning practices of students at the beginning of their first encounter with university and again towards the end of the first year of that encounter. To include repeat students or those who have had prior tertiary experience would confuse the analysis.

4.2.1 Sample Selection

Maximum variation sampling of the target population was used as described in the methodology section (section 4.1). The design of the selection process was based on three criteria: ethnicity, gender and measures from an inventory instrument – the MSLQ (Motivated Strategies for Learning Questionnaire - Pintrich, Smith, Garcia, & McKeachie, 1991) which has been tested and validated for psychology students at Wits (Payne, 2008). With regard to ethnicity and gender, selection aimed to produce a sample with a demographic distribution similar to that in the whole cohort of students. With regard to the inventory measures used, the intention was to maximize the variation in the learning practices of the students in the sample on the basis of what the inventory instrument indicated about their orientation to learning, their metacognitive self-regulation and their time and study management practice.

The procedure followed for the application of these criteria was as follows. Quotas for males and females in each of the ethnic categories African, Caucasian and Indian were determined on the basis of the demographics of the cohort. The list of students in the cohort was then divided into two groups according to whether their orientation-to-learning subscale scores from the MSLQ instrument were above or below the median for the cohort. Each of these groups were then divided into four additional groups according to whether their subscale scores for metacognitive self-regulation and time/study management were above or below the median for the cohort. Students were then picked from the resulting 8 student groups according to ethnicity and gender in order to satisfy the gender/ethnicity quotas and also to maximize the variation among the gender groupings in each of the three ethnic groupings. Initially, a sample size of 15 to 20 was

considered adequate to ensure sufficient representation of the varieties of learning practices found among the students. However, additional students were also selected as explained in the implementational details.

4.2.2 Data Collection

The data needed to address the research questions was obtained by interviewing the students in the sample early in the academic year and again towards the end of the year. The first interview focused on their learning practices at school and on their perceptions about whether or not different or modified learning practices may be needed at university. The interview towards the end of the year focused on the learning practices they were using at that time and a reflection on whether these had changed during the year and, if so, how and why.

All interviews were semi-structured as described in the methodology section. The interview protocols for the first set of interviews were piloted in the second week of the first semester of 2008 and the first set of interviews were completed within the following month. The second set of interviews was conducted at the beginning of the fourth quarter. The protocols used are set out in Appendix A (page 180).

4.3 IMPLEMENTATIONAL DETAILS

The MSLQ instrument was administered to the 2008 entering cohort during the first week of the academic year. Selection of students for the study then proceeded in two stages. The first identified candidates using the sample selection design described in the previous section. Eighteen students were identified in this way and were invited to participate in the study following the requirements stipulated in the ethical clearance letter for the study. The characteristics of these students are indicated in Table 4.1.

Table 4.1: Characteristics of Students Selected in the First Round of Selection

ETHNICITY	GENDER	RANGE ON 3 MLSQ SUBSCALES SCORES*		
		Deep orientation to learning	Metacognitive self-regulation	Time & study management
African	F	below	below	below
African	F	below	below	below
African	F	below	below	above
African	F	mid value	above	below
African	M	below	below	below
African	M	below	below	below
African	M	below	below	above
African	M	below	above	above
African	M	mid value	above	above
African	M	above	above	below
African	M	above	above	above
Mixed	F	below	above	above
Caucasian	F	mid value	above	above
Caucasian	M	mid value	above	above
Caucasian	M	above	above	above
Indian	F	above	above	above
Indian	M	above	above	above
Indian	M	above	above	above

* 'Above' and 'below' indicate whether the subscale score for a student fell above or below the mid-point ('mid value') of the range of scores achieved by the whole cohort of students.

A further 13 students were selected later in the study on the basis of knowledge gained during the first semester of the Process Course. These students were selected because they manifested what appeared to be interesting features or attitudes in their learning practices. Of these 13 students, ten were selected only after the first round of interviews had been completed and so were interviewed only once in the final quarter of the academic year.

Altogether, the sample consisted of 31 students, of whom 21 were African, 5 Indian, 4 Caucasian, and 1 of mixed ethnicity. Eleven were female and 20 male. The representation of Caucasian students was slightly higher than in the demographic distribution because they constitute a small minority of the class (about 9%) yet had a significantly different background from most of the other students in the class.

Of the 31 students, one withdrew after the first interview, and one left at mid-year. In addition, the transcript data from one student was discarded on the grounds of credibility; some of his responses clearly lacked authenticity and this cast doubt about the authenticity of his statements in general.

The interviews varied between about 40 minutes and 1½ hours. Each interview was recorded and transcribed. Transcriptions were performed by third parties. Each transcript was checked against the original recording by the researcher before proceeding with the analysis.

4.3.1 Data Analysis

The general methodology for analysing data in a phenomenographic study was described in Section 4.1.3. As indicated there, the objective of such an analysis is to develop categories of variation that together describe the qualitatively different ways in which people relate to, perceive or experience the phenomenon that is the focus of the study. The method used to do this in this study involved segmenting the interview transcripts into meaningful fragments, coding each fragment so that fragments with similar meanings could be collected together, compared and then analysed so as to develop appropriate categories of variation. Many iterations of these processes and many modifications to the segmentation and coding scheme were required before the final set of categories of variation emerged. A more detailed outline of the analysis of the data follows.

The interview transcripts were analysed using the ATLAS.ti text analysis software package. The first step was to gain familiarity with the nature of the data as a whole by skim reading all the transcripts and examining in more detail several that seemed particularly distinctive. During this phase of the analysis, interesting features from individual transcripts were coded in a fairly ad hoc manner. On the basis of the perspectives formed during this initial emersion in the data, a rough coding scheme was developed for the next stage of analysis.

The second stage in the analysis involved the segmentation of transcripts into relevant fragments based on the coding scheme that had been developed. The coding scheme was expanded as needed as successive transcripts were segmented. At several points during this process, the coding scheme was revised to more accurately reflect the distinctions that seemed to be emerging. Subsequent transcripts were then segmented

on the basis of the revised scheme. Several iterations of code revision were found necessary before all the transcripts had been segmented. The segmentation and coding of all transcripts was reviewed once a final coding scheme had been settled upon.

The third stage in the analysis involved a consolidation of the collections of similarly coded fragments into categories that were qualitatively similar. To do this, the networking feature of the software package was used. This involved placing each collection of similarly coded fragments onto the network, labelling each collection appropriately (usually with the code associated with that collection), and then re-evaluating what was distinctive about the collections. This re-evaluation process was facilitated by the networking feature of the software which allowed quick reference to the content of each fragment that had been placed on the network.

Collections that were qualitatively very similar were grouped together into categories. Sometimes in the re-evaluation process a new basis for distinguishing between the meanings of the fragments emerged and the network, codes, categories and the associations between fragments were adjusted accordingly. The categories that emerged from this consolidation and refining process constituted the final set of categories of variation from the phenomenographic analysis.

During the third stage of the analysis, it was found necessary to group the collections of similarly coded fragments into common themes and analyse separately the collections associated with each theme. The reason for this was that the collections related to too wide a range of themes and were too numerous for all of them to be accommodated on a single network. Accordingly, several networks were developed, one for each theme. The themes that were analysed in this way were as follows:

- Study engagements: How students reported going about studying on their own in order to learn and understand course material.
- Test preparation: How students reported preparing for tests or examinations.
- Classroom engagements: How students reported engaging with formal verbal input in the classroom (note taking and listening in order to learn).
- Motivation and dispositions: Students' dispositions, preferences and motivation relating to or affecting their studying and learning.
- Learning management engagements: How students reported managing their effort, time and work load and how they scheduled their work.
- Change: How students perceived they had changed in regard to any of the issues in the above list.

Several themes were not analysed at all (student background, first year experience, homework engagements, and reflection) because they were not very relevant to students' learning practices or because there was insufficient transcript data for a meaningful analysis. Some themes (help-seeking, peer study groups, and conceptions of studying, learning, and understanding) were analysed but have not been

included in the thesis because the results were not particularly insightful or interesting. Chapter 5 provides an overview of the results of the analyses and Chapters 6 to 10 describe the results in detail.

4.4 CONVENTIONS FOR PRESENTING EXTRACTS FROM INTERVIEW TRANSCRIPTS

In the presentation of the study findings in the following chapters, extracts from the transcripts are used to illustrate points being made. Normal conventions for presenting such extracts have been followed but with the following exceptions. Where the word choice of a student is peculiar or inappropriate to the extent that it makes it difficult to understand what they were trying to say, as evident from the rest of the extract, the offending words have been replaced by more appropriate words but within square brackets. Secondly, quote marks have not been used when extracts are presented as indented paragraphs. Thirdly, the style used when presenting extracts is intended to enhance the sense of conversational flow; statements by the interviewer and interviewee are not presented on separate lines but are distinguished by italicizing the statements of the interviewer. Fourthly, a referencing format has been used for each extract that 'identifies' the student and which interview set the extract is taken from. The format is [X/Y] where X is a letter-code student-identifier (ranging from A to AG), and Y is the interview number – 1 indicting the extract was from an interview at the beginning of the year and 2 from an interview towards the end of the year.

CHAPTER 5: GENERAL OVERVIEW OF THE FINDINGS OF THE STUDY

Previous chapters have explained the background to the study and the methodology and research design employed to address the research questions that have been posed. This chapter orientates the reader to the findings of the study in general. It provides an overview of the types of learning practices that have been identified and analysed in this study and explains how the findings have been organized in the chapters which follow. The chapter concludes by clarifying the meaning and usage of a number of key terms used in the analysis of the data and in communicating the results of that analysis.

5.1 OVERVIEW OF THE TYPES OF LEARNING PRACTICES INVESTIGATED

Chapter 4 explained the general method used to analyse the interview data and to identify the variation in the ways the students related to the various aspects of studying and learning. In summary, it involved a highly iterative process of segmenting the interview transcripts into meaningful fragments, coding these fragments, analysing similarly coded fragments for the qualitative variation that was evident in them, and developing categories of variation.

Early in the analysis of the study data, it became apparent that students' learning practices in different contexts were qualitatively quite different. Six contexts were recognized: the classroom; studying alone or in groups; preparing for tests; seeking help and managing one's learning effort. The study identified the following 8 types of learning practices associated with these contexts.

Mastering-oriented study practice: which is a combination of …
- … Theory-focused study practice and
- … Problem-focused study practice

Test preparation practice
Learning management practice
Classroom practice (including note taking and learning in lectures)
Help-seeking practice
Study-group practice

The essential nature of each practice is summarized in Figure 5.1 by indicating the context in which the practice is exercised and the focus of studying and learning in that context. The arrows in the figure give an indication of the inter-relationships between the different practices.

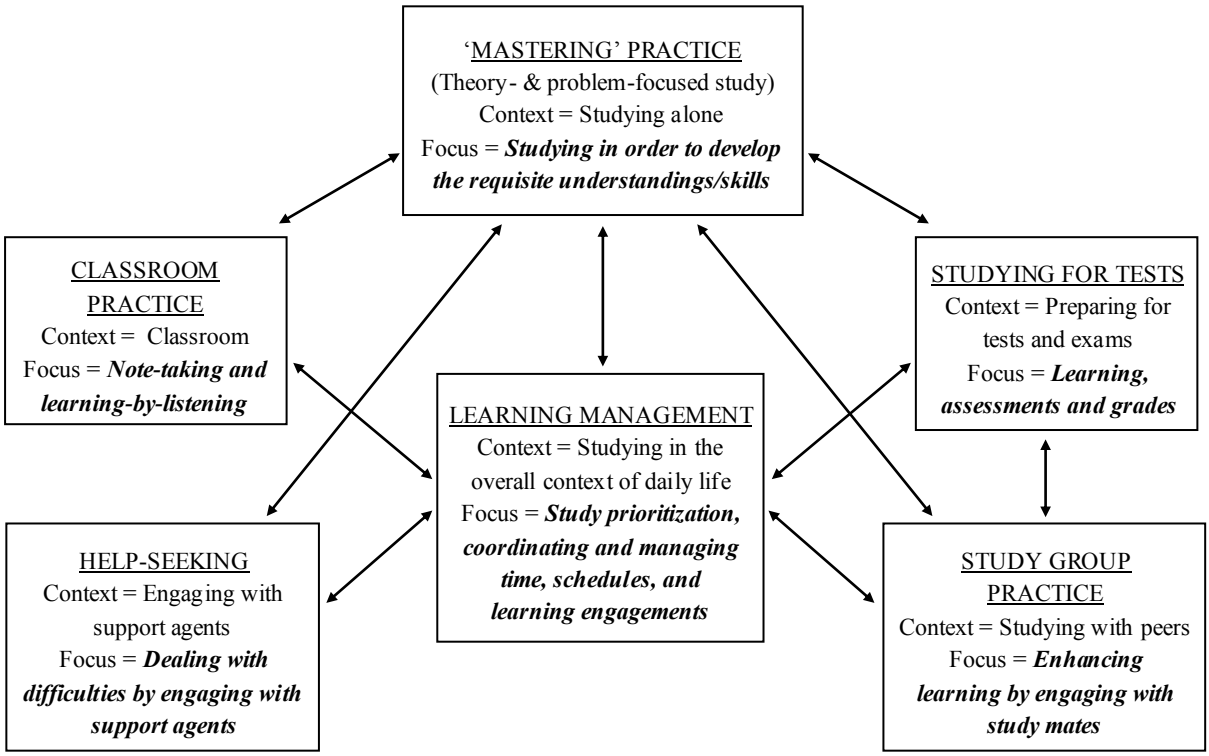


Figure 5.1: Contexts of Studying and Learning and the Learning Practices in Each Context

The way in which Figure 5.1 highlights the role of mastering-practice illustrates a key finding of the study, namely, that this practice is critical in determining the quality of a student's learning because it is focused exclusively on developing the understanding and skill perceived to be required by a course. That exclusivity of focus means that the attention to developing understanding/skill is minimally influenced by contextual factors, such as impending tests, that might dilute the focus on developing understanding/skill or divert attention away from it. Because of the pedagogical interest of the study (to improve student learning by facilitating an improvement in the quality of their learning practice) the study focused particularly on this practice and its component practices – theory-and problem-focused study practices.

As already mentioned, the focus, context and essential nature of each of the other types of learning practices were quite different and so each was investigated separately. This meant that 8 separate phenomenographic analyses were conducted. However, only 6 of these have been reported in this thesis because the interview data relevant to two of the practices – help-seeking and peer-group study practices – was not of a quality that allowed very meaningful or insightful analyses to be undertaken.

5.2 OVERVIEW OF THE PRESENTATION OF THE STUDY FINDINGS

The findings of this study are not presented in the manner normally found in a thesis where the results are presented first, followed by a discussion of those findings and the limitations of the study, followed by conclusions and recommendations. The reason is that, in effect, six relatively independent investigations are reported each focusing on a different aspect of learning practices. To give a clear and adequate report on the findings of each investigation it was necessary to give attention to the specifics relevant to that investigation alone – i.e. the analysis of the relevant interview fragments, the identification and explanation

of each of the categories of variation, the formation of the relevant outcome space, and the analysis of the structure of that outcome space.

Accordingly, it was considered necessary to present the analysis, findings, and discussion associated with each practice as a unit in a chapter of its own or as a unit in a part of a chapter. Because particular attention has been given to theory- and problem-focused study practice and to mastering-practice, a separate chapter has been devoted to each – Chapters 6 to 8. The remaining three types of learning practice are presented in Part A and B of Chapter 9 (test-preparation and learning management practices respectively) and in Part B of Chapter 10 (classroom practice). These chapters and part chapters constitute the study's response to research questions – *What is the qualitative variation in the learning practices of our students when they enter the university (Question a) and which they develop during their first year of study (Question b)?* The study findings in respect to the third research question – *In what ways do our students perceive that their learning practices have changed during the course of the year?* – are presented in Chapter 10. Chapter 11 draws together the findings from all 5 chapters. Chapter 12 concludes the thesis with a discussion of the limitations of the study, recommendations for further research, how the study findings resonate with the literature, and a summary of the theoretical developments that have emerged.

5.3 GLOSSARY OF KEY TERMS USED IN THE ANALYSIS OF THE DATA

Several key terms are used in this thesis in very specific ways and, because of their importance to an understanding of the analysis of the data, these are highlighted and discussed below before the analysis and the study findings are presented.

Course material: Course material is taken to mean the content of a course as conveyed primarily in texts such as teacher hand-outs, textbooks and supplementary texts including, for example, the 'Study and Masters' and Pythagoras study guides which were widely used at school by many of the students. Lecture notes taken by students also constitute 'course material' in that they constitute a written record of the content of verbal communication by teachers with regard to course content.

Learning and studying: In this thesis 'learning' is taken in the educational sense to mean *assimilating information, or developing understanding or skill.* 'Studying' is taken to mean *an activity in which a student intentionally engages with course material (including problems) with the intention to learn.*

Engagement and practice: These two terms, when used in the sense of 'learning engagements' and 'learning practices', are distinguished as follows. An engagement is taken to refer to a current activity – an 'acting in the moment' – in contrast to a practice which, according to the definition in section 3.10, is an orientation to engage in a certain way that has been developed from prior experience.

Theory and Problems: The distinction made between 'theory-focused study practice' and 'problem-focused study practice' derives from the structure of science, maths and engineering courses which typically present students with both 'theory' and 'problems'. Here 'theory' is referring to 'bookwork' and

is taken to mean *the conceptual and theoretical knowledge and information presented in course material*. 'Problem' is used in a technical sense as commonly used by the students and in these kinds of courses. I define its meaning as follows: *a question or difficulty that cannot be resolved without some kind of numerical or mathematical* manipulation. In principle, problems may be closed in nature (having a well-defined and 'correct' solution) or more open-ended in nature (having possibly more than one solution, any one of which may be 'appropriate' as opposed to being 'correct'). In their first year programme, the 'problems' which students encountered, even complex problems, were almost entirely closed in nature and this is the sense in which the term is used in this thesis.

Know-how: The terms 'know-how' or 'practical know-how' refer to the kind of expertise that derives from a deep understanding of a particular domain of knowledge and extensive experience in applying that knowledge in real world situations. In more formal terms, I define it as follows: *the ability to function in the world with explanatory and predictive power, possessing a high level of practical and conceptual mastery with regard to how some domain of the environment is understood to work and how that understanding can be deployed to exercise appropriate control over that environment or to design and operate systems that function effectively within the constraints imposed by that environment.*

Mastering: This is a particularly important concept in this thesis, and is used in a very specific manner. It conveys the idea of learning which is oriented to personally mastering course material and the related skills – i.e. personally getting on top of what is being learned, however 'getting on top of' is conceived by the student. The term 'mastery' is generally avoided in this thesis because of connotations emanating from the paradigm of 'mastery learning' (Bloom, 1968, 1971) and the implication that reference is being made to externally preconceived standards or levels of expertise. In this thesis, *such connotations are explicitly excluded when using the term 'mastering'*.

CHAPTER 6: DATA ANALYSIS AND RESULTS 1: THE VARIATION IN THEORY-FOCUSED STUDY PRACTICE

As outlined in the general overview in the previous chapter, this results chapter, the first of five, presents the study findings relating to the context of studying alone and focusing on 'theory' (or bookwork as opposed to 'problems') with the intention of mastering the material being studied. Other intentions, such as preparing for tests/exams, are not in view or are peripheral and do not influence the commitment to engage with the material being studied on its own terms. The label that has been given to this type of learning practice is *theory-focused study practice*, sometimes abbreviated to theory-focused practice or theory-focused study. As mentioned in the glossary (section 5.3), 'theory' is taken to mean *the conceptual and theoretical knowledge and information presented in course material.*

The findings presented in this chapter derive from a phenomenographic analysis of interview fragments relating to theory-focused study practices following the methodological procedures described in Chapter 4. In outline, this chapter presents the results of the analysis that has been undertaken; an interpretation of those results; and some empirical support for the conceptual relationship discovered between theory-focused study practice and the quality of learning which it affords. The presentation begins with the detailed findings about the variation in theory-focused-study engagements.

6.1 THE CATEGORIES OF THEORY-FOCUSED STUDY ENGAGEMENTS

From the analysis of the relevant interview fragments, it was found that the variation in theory-focused study engagements could be described in terms of five qualitatively different categories. These have been labelled as follows:

Information-oriented study engagements
Comprehension-oriented study engagements
Consolidation-oriented study engagements
Refinement-oriented study engagements
Know-how-oriented study engagements

Each category is now described in detail along with an explanation of its distinguishing features.

6.1.1 Information-oriented study engagements

In this category of study engagements, the focus of attention is the learning of facts, formulae, or information: "[We] would just have to learn facts, like history for example, you just had to learn facts" [C/1]. The method employed to learn such information is repeated reading – "just trying to cram facts into your head" [AA/2] – sometimes combined with a memorization technique of some kind; "I would read something through and through and then know to say it without looking on that page. Just, I don't understand that thing but I can say it" [T/1]. The latter extract illustrates a characteristic feature of this

type of engagement; i.e. the intention of 'learning information' is to gain familiarity with the information or to memorize it with little or no particular regard for comprehending it – that is for making sense of it or for understanding its relevance. Any comprehension that may result from the engagement is incidental to the immediate intention of that engagement.

It was found that three qualitatively different kinds of learning practice involve the assimilation of information: assimilating information, memorizing information, and cramming information. Each of these utilise essentially the same kind of learning strategy, that is, repeated engagement with the information to be learned. However, the engagements differ with regard to the intentions behind this strategy. The latter, 'cramming', has the intention of learning information for the purpose of reproducing it in an upcoming test or examination. 'Memorizing' may have this intention as well but may also have the same intention as 'assimilating' which is to learn information as a first step towards understanding it. Because of the similarities between the three types of engagement they are all analysed and discussed here even though 'cramming' (and sometimes 'memorizing') are essentially test-focused study practices and are discussed in more detail in Chapter 9 along with other test-focused study practices. The characteristics of the three types of engagement are now explained and illustrated.

Assimilating information

What characterizes this subcategory is that the primary intention of 'learning information' by repeated exposure to it is to 'assimilate' that information as a prelude to subsequent engagement to comprehend it or use it; assimilating information – becoming very familiar with it – is seen as a necessary first step in a larger learning process. The following extract illustrates the nature of this type of engagement.

> I've noticed … we wrote a history [of technology] test the other day and I noticed that I had to basically learn content. And then when I knew the content I could kind of sit and think about it… and mull over it and kind of form opinions and interpret things. But I just had to cram everything in [assimilate it] and kind of take an entire essay reading pack and just learn it. [AA/2]

In this extract it is evident that, although the student was studying in preparation for a test, the primary intention behind learning the information was not to develop the ability to reproduce that information in the test but to assimilate the needed information as a prelude to thinking about and reflecting on that information and by so doing to develop an understanding of its relevance and meaning.

Memorizing information

In this subcategory, the intention goes deeper than wanting to assimilate information; the aim is to commit the information to memory to enhance retention of that information. The following extract illustrates the use of a memorization technique using a form of mnemonic. The individual, student F, used the technique in conjunction with other study engagements that were oriented more to understanding; as such, the intention was both to enhance recall and to consolidate mastery over the relevant information.

> I think I partly have quite a good photographic memory so it was ok for me to understand and to learn. … I often revised it [biology] so it formed this path, what I call like a highway. … a journey from your house to varsity and track back, give yourself ten [reference] points. You get out of bed, you go to the door etc until you get to varsity, and then link that with something. An elephant was at the door. There was a green mat at the window. In the car I saw a mouse. So when you start building a mental picture there and you repeat, it sticks. …Drive down that

> highway once [and] it's going to stick for a day. Go through the highway over and over and over again, it forms a path, a channel in your brain or whatever you want to call it. Where it's repeated, it's almost engraved, it's there. So for me repetition really was a good way to do it. [F/1]

The following extracts illustrate the memorization of information as a means of enhancing recall for tests/exams. The individual, student V, labelled her memorization technique as 'parroting'.

> *What about the theory in maths? How did you learn that?* Parrot learning. I just read it and I'll try to remember it. *Tell me how you'd do that?* I'd read it over and try – yes, I just read it over and over and try and remember it, that's all. Most of the time I didn't understand what I was reading but I just wanted to know - I had to remember what I read. *And did it bother you that you didn't understand…* I did understand it but not fully, fully, fully. Sometimes I did understand those particular sections of maths, sometimes I didn't. [V/1]

> *Was there no 'parrot' with science?* There was also parrot with science. Because …there's a lot, a lot of notes for science, especially chemistry. Sometimes there was some parrot learning. *Your smile, suggests to me you didn't think parrot learning was a good idea.* I don't think it is a good idea. *Did you think it was a good idea then?* Yes, I did. Because sometimes…you just want to like if you have a deadline, you have to learn for tomorrow …you just have to learn…I just parrot learn everything. And then after you parrot learn it, the next day maybe you just forget it, after you write. That's the thing I hate about parrot learning, you don't remember it after maybe a week or something. *Why did you do it then?* Because it was faster, you could learn faster. [*Laughs*] For me it was faster. *But what was forcing you to learn this that way? Was it for a test or something?* Yes, like tests. Like mid-term tests. *So when did you parrot learn, all the time or just before the test or what?* Before the test. [V/1]

Cramming information

The intention guiding this subcategory of study engagements is to learn facts, formulae or information for recall in an imminent or pending test or examination by using some kind of memorization technique or intense last-minute exposure to the information to be learned. The intention is typically short term; "when you cram stuff in your head … You don't remember what you've done for the previous test because you've just crammed it, short term – in and out you know" [A/1]. This category is addressed in more detail in Chapter 9 (section 9.1.1) in the context of test-preparation engagements.

6.1.2 Comprehension-oriented study engagements

In this category of study engagements, the focus of attention is the comprehension of course material as it is being read; textual material is the only resource used in this kind of engagement. While students generally described the intention behind such engagements as trying to understand the course material, it is more accurate to describe the intention in terms of comprehension; the focus is on the course material as it is presented and involves trying to make sense of it and to comprehend what it means. The intention is not primarily to make deeper conceptual connections, or to consolidate or restructure the material to make it one's own – which are the intentions that characterize the more sophisticated study engagements described next. Such conceptual refinement may be forthcoming but only as an indirect consequence of the engagement; the intended focus is comprehension so that the meaning of the material becomes clear to them. Students talked about 'consuming' the material [S/1] so that 'it sinks in' [E/1], 'it clicks' [J/1] or 'you get it' [H/1].

Three subcategories of comprehension-oriented engagements were evident in the students' reports and are distinguished by the type of activity which the engagement involves – reading through, going through or working through.

Reading through: *(Single reading of the material)*

Here the engagement takes the form of a single reading through or review of the course material or parts of it with the intention of refreshing one's current comprehension of that material or reminding oneself about its content.

> *But you still did go back to the textbook?* Yes I did yes, *Regularly?* Umm, maybe like for a test, I would just read through it once just to check if I didn't miss anything. [AE/2]

Going through: *(Multiple re-readings of the material)*

Here the engagement involves repeated reading of course material – "going over and over it" [G/1] – until a satisfactory level of comprehension is perceived to have been achieved – for example reading until 'it clicks' [E/1]. It is a relatively passive approach to gaining comprehension of the material; the material is re-read multiple times in the expectation that through repeated exposure to the material comprehension would somehow 'arrive'. It does not involve the more pro-active kind of 'struggling with the meaning of the text' which is characteristic of the next subcategory. The following extracts from Student G illustrate this type of engagement.

> *I'm very interested in how you studied those notes.* I would like read them until I understand, … That's what I did. [G/1] … Go over and over. [G/1]

> *How did you learn biology?* I would read my notes. She would give us notes on the topic, and then we'd copy them into our books, and [then I would] then read those notes *... Is that all you did, you just read and re-read, or what?* That's what I did in biology. *Summaries? Sketches? Underlining?* We never used to do that. [G/1]

Working through: *('Wrestling' with the material)*

In effect, 'working through' is a careful, reflective reading of textual material in which the student works proactively and methodically with the material to gain an understanding of what it means and what it is about. This type of engagement is similar to 'going through' course material only in the respect that the material is read through several times and that the intention is to comprehend the material. It differs significantly in the way in which the material is read and in regard to the perception of how comprehension is gained. Where 'going through' involves the activity of simply reading the material, 'working through' involves additional activities such as pausing at times to reflect, re-reading difficult sections, and, in various ways, testing one's understanding of what has been read as one reads it. This more proactive engagement with the textual material is based on the conception that material must be wrestled with and worked on in order to gain a level of understanding that is deeper than that which just 'arrives' by simply reading through the material a few times. The following extract illustrates these aspects.

> What I try and do is read it once through and sort of get a broader idea. Read it a second time through, pick up anything I've missed and then read it a third time, sort of pick up the main points and the… overall... topic really. Pick out the key points, of what I'm reading. So generally 3 times works for me, I tend to pick everything up. ... The first time is just generally a skim through and then… just get what it's about. The second time you pick up on other things that you missed, details. And then the third time is definitely like a, sort of evaluating that you have to like look at everything and uh… re-read it. *What if it's quite a long section? Still read three times?* Yah, generally. Um, maybe split it into bits, read the first 2 paragraphs, like that. Then read the second 2 paragraphs. … So, split it up into little bits. [AA/2]

Although 'working through' material involves activities that are additional to simply reading the material, the engagement still only works with the structure and content of the material as presented to the learner; it

does not include activities aimed at changing or re-arranging the structure of the material or of reducing its volume or summarizing it – features which characterize the next two categories of study engagements.

6.1.3 Consolidation-oriented study engagements

The focus of attention in this category of study engagements is to deepen the comprehension of course material using some kind of reinforcement and consolidation strategy. What characterizes this category and distinguishes it from comprehension-oriented engagements is the intentional use of comprehension-enhancing or material-consolidating techniques in addition to or alongside the activity of 'working through' course material. In other words, this type of study engagement is an advance on the previous one in that it does more than engage with textual material, it also uses consolidation techniques – 'tools' – of one kind or another to facilitate the consolidation of what is comprehended when reading the textual material.

The use of 5 types of techniques was evident among the students and these constitute 5 subcategories which have been labelled 'highlighting', 'vocalizing', 'memorizing' for understanding, 'summarizing', and 'applying'. Each subcategory is described below in more detail.

Highlighting

This category of study engagements involves highlighting/underlining key points in texts that are being read.

> For example I will write a sentence out and then I'll highlight the keywords of the main phrase of the sentence. *In the notes?* Yes in the notes. [AB/2]

Highlighting can be undertaken merely as an almost incidental activity accompanying careful reading which would make it little more than a comprehension-oriented study engagement. However, it is an activity other than reading; it leaves behind a record that can be useful in subsequent study; and the activity can facilitate a deeper level of comprehension because it requires the reader to think about the material and make decisions about what is important enough to highlight.

Vocalizing

This technique aims to reinforce understanding by vocalizing the subject matter in some way as the following extract illustrates.

> I talk to myself and try to explain it to myself when I read [the material]. And you actually sit there [saying to yourself] so this is this…My mom was sometimes surprised when she heard talking. Because I did it loud, I thought it sinks in best if you talk to yourself loud … Just do it in your head [and] it's like scrambled eggs. Whereas if you talk it out [it sinks in]. [E/1]

Vocalization can also be used with the intention of facilitating the memorization of information; for example, the above student said "it sinks in best" when vocalizing, implying that this activity can enhance the commitment of information to memory. However, the intention behind the activity described in the extract goes beyond that of memorizing; 'vocalizing' was used as an intentional strategy to enhance understanding. The student implied that the activity helped to 'unscramble' his ideas as he explained to himself out loud "this is this" etc.

Summarizing

This subcategory of consolidation techniques involves consolidating the comprehension of course material by means of writing some kind of basic summary or summary list such as topic lists, key points, margin notes, or short extracts from the material being studied. These 'summaries' are quite basic in nature in that they are essentially only extracts from the material being studied; they are not the result of any genuine restructuring or embellishment of that material and any modification to the information extracted is only superficial in nature. These features of the summaries distinguish them from more sophisticated techniques such as the writing of study notes or a précis of the material being studied, all of which constitute a restructuring or embellishment of the content in order to 'make the material one's own'. This more advanced kind of restructuring is characteristic of the more sophisticated study engagements discussed later in section 6.1.4.

The following extracts demonstrate the essential features of this category of consolidation-oriented study engagements. The first illustrates the awareness that writing a summary enhances understanding.

> *What do you have to do to get deep understanding?* ... you have to summarise some of the important material… because if you summarise that little bit of the material you are conscious about what you have summarised so you are able to know. You don't forget this. [I/2]

The following two extracts are interesting for several reasons. While they illustrate the use of topic lists it is not immediately clear whether the intention behind this usage is the memorization of information, the enhancement of understanding, the development of notes for future study, or memorization combined with understanding. A closer reading of the two extracts taken together – they are both from student M – shows that the engagement intends towards all four objectives.

> I would write like sub topics, … I would like study [my] notes and I'd write sub topics and then study and then close my notes. And then I would look at this piece of paper with all the sub topics, and then when I read this I will try to recall whatever thing that's related to it and write it down. Relate to the sub topic like bonding. Like I'll write that three times … [the] different characteristics and then after that I will like open my books and see what could I remember, what did I miss, what can't I remember and then I will do it again. Do the same thing until I can remember the whole thing and the data from my notes. I will do the same day without opening it to see did I really understand it or was I like cramming for that time. [M/1]

> *How was that different from memorising?* Memorising is like studying something without understanding it. How it's different is, after two days that's what I did so, I kept this…I took them seriously – sub topics – so I kept them like in my file. I took them out and then like after three days and then look at the sub topics and do the same thing and see if I'll be able now to write a paragraph about the sub topic. That's how I do it. *Then you checked.* Then I checked. So I kept this like in my file and when it's December I don't have to go through my notes like I did in [the previous] January, I'll just take the sub topics and then do them like I did, and I'll check, I'll compare. And then what I don't understand is, what is not here and what my little summary from my notes then I'll see that something…that's the point I'm missing. Then I don't have to go through all my notes again. [M/1]

As is evident from the above extracts, 'summarizing' consolidates and reinforces the comprehension of course material in any of three ways: by including an additional activity while reading the material; by the act of consolidating that material; and by producing additional material – the written 'summaries' – which can be used for study at some later stage.

Memorizing with understanding

The activity of memorizing has been mentioned twice already – once as an information-oriented study engagement (section 6.1.1) and once in the previous subcategory in relation to 'summarizing'. The activity

is recognized here as a consolidation technique because here it involves the memorization of principles, and meanings – in effect, it constitutes memorization with understanding. The following extract illustrates the nature of memorization-with-understanding and demonstrates how this type of memorization activity reinforces the comprehension of theory and so is recognized as a consolidation technique.

> *You memorise?* Yah. But now, eh, what you memorise you have to understand it … *So, it sounds to me that memorising is still important to you.* Yeah, it's still important. *But now the difference is memorising with understanding.* With understanding. ... *What do you do?* Like if I memorise … something like maybe you are doing a reactive balance, I [might] memorise a key word, and … how to do that thing with that key word, the explanation of some purge stream… like why we [use] a purge stream … things like this. When you are solving problem, it's kind of like easy for you because you know, what is the purpose of that thing, why it's like that. You memorise that information you know it, it was not easy for me to forget it. *Well, that's just memorising, what about the understanding part?* The understanding part is like… you need to understand what you have memorised, like if you memorised this thing is supposed to do like, you have to know why it is like this and to know it. *Okay, do you memorise first and then understand or do you understand first and then memorise. Or does it all happen together?* No it like… you understand first then you memorise. [I/2]

Applying

This category of study engagements involves consolidating and reinforcing comprehended theory by means of applying that theory in the solving of problems. Appropriate problems are selected and worked on for the express purpose of consolidating one's grasp of the theory. This type of engagement constitutes a point of intersection with the problem-focused study engagements to be addressed in Chapter 7. As will be seen there, the solving of problems is integrated with the learning of theory in various ways. What is characteristic about the category 'applying' here is that the integration of theory with problem solving is undertaken with the specific intention of reinforcing the understanding of theory. The following extract illustrates this. It also illustrates how the practice, like other consolidation-oriented engagements, works within the bounds of the existing structure of the course material as presented to students.

> *How did you use your study guide?* I read through a paragraph that explained something and tried to understand it with the diagram that was next to it, and then the study guide always had like two or three practice questions and I tried those. Well I tried the first one with the answer. If I got the wrong answer then I went back into it [the theory], read through it again to figure out exactly what's happened and then tried [the question] again. If I got the right answer I went on and I tried all of them to see if the concept was fine. …*With the study guide did you do anything else?* Yes, I learned out of it. Did the practice questions that they had in there. It was very obviously set out, like paragraphs… *So to what extent did you actually rely on the actual structure of the study guide?* I think throughout. They went by chapters so whatever you were doing at school you'd use that chapter out of the study guide. It was like a chapter that builds up on each other, so, I guess you can only start at the beginning. [E/1]

6.1.4 Refinement-oriented study engagements

The focus of attention in this category of study engagements is to deepen personal mastery over the theory that has been comprehended and consolidated, and to do this through the agency of refinement 'tools'. These tools consist of strategies, techniques or processes that work on one's current understanding of theory to build it further, to modify it or elaborate it in some way – in other words, they 'refine' that understanding. The essential nature of refinement-oriented study practices is best explained by first presenting and discussing typical examples of the tools/strategies students used. Six examples are given below.

a) Self-questioning and 'what-if' questioning

Here the student interrogates his understanding of the theory to deepen his grasp of it.

> The way I understand some things is that I look at it and then [say to myself]… this is what this is, and then I sort of ask myself a few questions about it, like, ok, fine, this is what this is in this situation, but what if? What if this were to happen here and then what happens? Then if I look at it from the other way around what happens then? I usually just play around with the concept and that, put a few figures [numbers], if it's a formula put a few figures in it…that's one of the ways that our science teacher actually taught us that when you're studying a formula for matric, don't learn it this way, … look at your units to actually understand what you're talking about and that … know what those units are and where they derive from so that you can have a better understanding. [U/1]

b) Expanding one's notes and integrating multiple sources

Here, the student intentionally seeks and incorporates additional material and elaborates her notes accordingly.

> *Do you look at the text books a lot?* I do when I'm not completely understanding something and I need to go back to the beginning and see exactly…so yes, I do do that. Because I find that the notes we get in class, they're good notes, but sometimes you need to expand on that for your own self you know. [A/1]

> [I consult] lots of different text books, lots and lots of different exercises, exercises from each different text book. Because they ask the questions in so many different ways if you go through different text books. That really helped me a lot. ... I found some text books would question or examine things in one way…and all their questions would basically be the same. Whereas if I went over different text books with different questions, it made me feel more…I think the word is secure in my work that I knew what was going on because I had gone through different examples. [A/1]

c) Restructuring notes and using problems to enhance understanding

Here the student develops study notes and, to some degree, restructures them and uses these to clarify and reinforce their understanding of the theory before deepening that understanding by attempting problems.

> What I do is, I often make myself notes, colourful notes and it's easier now because I use my lecture notes and I try and make the notes ordered and structured and as colourful as possible, and I use that as my study notes to get a general view. After that I'll refer to my text book because there's often things I've missed or haven't been spoken about in the text book. … Then I'll go and do the actual [problems] or the practice, and that's how it works. … And then I start my problems. [F/1]

d) Developing condensed study notes

Here the student develops a condensed précis of the material and, before studying from it, makes sure it is easy to understand and includes all the important points.

> *How did you learn the theory?* Generally I tried to summarize it into as condensed a form as I could and then just learn it…I wouldn't say parrot fashion, but just learn the principle behind the condensed version and then just… *How did you get to the principle?* Again, it's just condensing all the theory that was given to me and then just trying to make it as easy to understand as I could without losing anything. [C/1]

e) Developing concept maps

Here the student uses concept maps when studying because of the way they highlight connections and provide a different perspective on the theory being learned. In the following illustration of this the student refers to concept maps as 'mind maps'.

> I enjoy studying using mind maps. That was from grade 7 to grade 8, and then I sort of stopped using mind maps like for chemistry and that, just because of the way the whole schooling system was structured and that. [U/1] … *How do you think mind maps aid understanding?* Well mind maps aid understanding in my opinion because you show connections between concepts. And you don't see a particular topic within one dimension. [U/1]

f) Enhancing understanding by visualization

Here two students talk about how they worked off mental pictures of the theory to aid their learning.

> *How do you know when you have an understanding?* If the content makes sense to me and I can visualise it and I understand it. ... When it makes sense to me and I can actually visualise it. ... *Tell me about visualising* ... I just really try to picture what's going on, like, maybe if they tell you … right now we're learning about electro magnetism and if I can visualize it and see what's actually going on, and then I know that I understand the work. *So visualise? Is that pictures?* Pictures, pictures, yes. *In your head?* Yes as strange as it may seem, ja, its pictures. [AB/2]

> I just remember like one good piece of advice our teacher once told us when it comes to science and stuff – think with your pencil, think visually … "Draw a picture", she would always tell us, and "just think about how it would apply to the picture instead of just trying to work it out in words". [C/1]

Examination of the six examples presented above gives insight into the intention behind the engagements described and also shows that there are two qualitatively different types of refining tools/strategies that the students were using. These are labelled 'restructuring' and 'connecting'.

In one way or another, five of the examples above involved a restructuring of either the textual material the student was working with or of their conception of the associated theory. The most obvious instances of this are the restructuring of notes, condensing them, and elaborating them, and also the developing of concept maps – respectively items (b) to (e) above. Visualization – item (f) – involves what amounts to a mental restructuring of some aspect of the theory a student has developed and internalized. It seems unnecessary to point out that any restructuring of notes and any drawing of concept maps – that is, any external restructuring activity – must surely also be associated with some degree of 'internal' restructuring of the student's mental structures as well.

The kind of self-questioning and 'what-if' questioning illustrated in item (a) in the above list are examples of a student trying intentionally to make new connections in their conceptual understanding by interrogating that understanding and intentionally trying to find fresh perspectives from which to do so.

Students who manifested refinement-oriented study engagements did not describe what they were doing in terms of refinement. If they attempted at all to describe the intention behind such engagements, they tended to express it rather generally in terms of 'deepening their understanding'; this is quite evident in the six extracts presented above. However, student AA was somewhat more forthcoming and gave, in effect, a constructivist view on the nature of his study engagements and of the intention behind them.

> I think knowledge is a sort of building process and you have to have the basics and I'm very glad that someone has gone before me and figured out what I need to know, and sort of… put together an entire syllabus for me. You have to get the basic concepts and then build on them and I've noticed in a lot of courses it gets more abstract. You look at things and you have to think a whole lot more and interpret and sort of form your own opinions about certain things. *Do you enjoy that?* Yes definitely it's, it's nice to do that. I think it's good to think about things and interpret them and get your… own ideas about them. Because ultimately that's what you're going to be using … your own sort of knowledge and your knowledge construct. [AA/2]

The kind of 'restructuring' activities and 'making connections' that have been discussed and illustrated here correspond closely with the kind of activities which Entwistle et al. (Entwistle & Entwistle, 2003; Entwistle & Marton, 1994) have described as leading to the development and refinement of 'knowledge objects' (see section 2.5.2).

In essence, the focus of attention in refinement-oriented study practice is the refining of consolidated theory in order to develop a personally refined grasp of disciplinary knowledge and skill. Refinement-oriented study engagements may be conflated with consolidation-oriented engagements – this is fairly clearly evident in four of the six extracts (b to d and f) – but can nevertheless be distinguished as a qualitatively different type of engagement on the following basis. In consolidation-oriented study

engagements, the focus of attention is theory that has been personally comprehended – made sense of – and the intention is to consolidate that personally comprehended theory using consolidation tools. The structure of course material as presented to the student constrains consolidation activities because the focus of attention is to understand the material as presented. In contrast, with refinement-oriented study engagements, the focus of attention is theory that has already been comprehended and consolidated and the intention is to deepen that understanding by developing and refining knowledge objects using refinement tools. In the attempt to restructure conceptions and/or to make new conceptual connections, refinement engagements explicitly look beyond the conceptual structures of both the material being studied and the students' existing conceptual structures. Hence refinement-oriented engagements are not constrained by the structure of the course-material-as-presented in the way which consolidation-oriented engagements are.

6.1.5 Know-how oriented engagements

The focus of attention in this fifth and final category of theory-focused study engagements is practical know-how which has to do with a depth of understanding, skill and experience that enables effective practical action in real world situations. (A more comprehensive definition of know-how is given in section 5.3.) None of the students explicitly talked about or manifested the intention of developing practical know-how defined in this way; the level of expertise associated with such an aim is perhaps too much to expect school leavers or first year students to develop. However, there was evident among some students a way of learning that was more advanced than reinforcement-oriented engagements in that it involved thinking about how what was being learned applied to real world situations. Although this way of learning did not explicitly involve the intention to develop know-how as such, it did involve, even depend on, thinking about the real-world application of the theory being learned as an explicit strategy for developing understanding of that theory; it was implicitly oriented to the development of practical know-how. Student AA, in particular, manifested this kind of orientation at many points in his interview. The following collection of his remarks serves to explain the nature of this final, most sophisticated category of types of study engagements.

> I'm not a big fan of just purely theory. I need to see how it works. If there is a practical sort of use for it I think it's a whole lot better because I can see it in action and actually see how the concept goes from being sort of abstract thought into… a physical thing. [AA/2]
>
> And then, I think for me, definitely the application is very important. I have to see how it works, if it works… and where it works too in order to understand it better. So, I need to do that sort of easy example, an example of it to understand how it works. [AA/2] … To understand enough to be able to apply it to a real life situation. And I think everything sort of culminated one day and I thought… you know I'm actually… learning something, understanding a bit better. I kind of know what I'm doing now; I know why I'm doing it. Instead of being able to just go and do a sum, I kind of understand why I'm doing it, where I might be able to use it. [AA/2]
>
> I find... I enjoy interesting things … initially I didn't find process very interesting, but as we got on to … sort of real life applications … looking at the … desalination process and stuff. I find that very interesting, it's probably used and it's probably something I might see one day as a process engineer. So, uh… I like knowing that the work has a purpose. [AA/2]

What characterizes the study engagements in this category is the orientation to practical application in real world situations. In previous categories, study engagements were oriented to the content of the course and the various types of engagement practice were more focused on gaining mastery of course material and the related skills than they were on developing the practical understanding and experience needed to address

real world situations. Know-how oriented study engagements, on the other hand, are influenced significantly by the students' interest in how the world works and how what is being learned 'fits' or 'opens up' or 'applies' in the world – as the above extracts from student AA have illustrated. Student C went as far as describing his level of interest in terms of a "fascination" towards and "being grasped by" the application of 'science' in real world situations. In the following two extracts, Student U describes how the motivational impact of that kind of interest dramatically influenced his study engagements.

> *How did that kind of drive that you just described affect the way you learned?* Tremendously. Because I wasn't just learning something for the sake of learning it, I was learning it because I found it useful. And by finding something useful it would poke me and poke my curiosity and I'd begin to ask questions, and I'd learn something but I'd take it beyond that. Like for instance when we started learning calculus I'd want to immediately jump to integration and that because I'd get so excited. [U/1]

> In standard six, standard seven I somewhat struggled with maths, not because I wasn't good at it, but just a lack of interest. So I did a hobby that actually forced me to apply my maths and science because my whole attitude was, why must I learn this if I can't apply it? So I started building rockets and learning about principles of rockets to sort of really see Newton's forces in action or see whatever I learn and use it in a practical sense. That's what kept me interested, and the moment I did that, my marks shot up by 20%, 10%. [U/1]

In particular, what distinguishes a know-how oriented study engagement from the previous category (refinement-oriented engagements) is the intention and consequential action to relate what is being learned 'to real life'.

6.1.6 Summary and discussion of engagement categories

The results presented in this part of the chapter have identified five qualitatively different categories of theory-focused study engagements. Three features characterize each category: the intention of the engagement, the types of engagement strategies used, and the type of resources used by those strategies.

The intention characterizing each category can be described in terms of the type of knowledge which the engagement is focused on developing. Specifically, information-oriented engagements are oriented to the learning of information; the focus or intention is the development of 'learned information'. Comprehension-oriented engagements are oriented to the comprehension of course material, or, put differently, to the development of 'comprehended information' or, more comprehensively, to the development of 'personally comprehended theory'. Consolidation-oriented study engagements are oriented to the reinforcement, consolidation and integration of comprehended theory, or, put differently, to the development of 'personally consolidated theory'. Refinement-oriented study engagements are oriented to the development and refinement of knowledge-objects or, put differently, the development of a personally refined grasp of disciplinary knowledge. Finally, know-how oriented engagements relate a student's grasp of disciplinary knowledge to real world situations and, by so doing, facilitate the development of practical know-how in the relevant disciplinary area.

Each engagement category utilizes a characteristic type of resource or 'tool'. The first two – information- and comprehension-oriented engagements – both work on textual material. Consolidation-oriented engagements work on textual material as well but, characteristically, also use one or more types of consolidation 'tools' (such as *highlighting*, *vocalizing*, *memorizing*, *summarizing*, and *applying* theory).

Refinement-oriented engagements also work on textual material and may also use one or more consolidation tools but, characteristically, employ one or more types of refinement tools (such as restructuring, self-questioning, elaborating, concept maps, or visualizing) that restructure notes or conceptions and make new conceptual connections. The resources/tools that characterize know-how oriented engagements include a student's knowledge about the world, their curiosity about real world situations, and the disposition to relate their understandings to real world situations.

Table 6.1 (on the next page) summarizes the categories that have been identified. (To make reference to the table easier, the reader may like to fold out the copy of the table in Appendix B, page 183.) The categories have been arranged in order of the degree of sophistication in the nature of the study engagement. The sequence is explained as follows. Comprehension-oriented engagements are more sophisticated than information-oriented engagements in that the former specifically attempts to make sense of information in a way that the latter does not. Consolidation-oriented engagements are more sophisticated in that they involve strategies and resources that comprehension-oriented engagements do not use and they consolidate the student's comprehension of theory. Refinement-oriented engagements are more sophisticated still in that they use additional strategies and resources that intentionally refine and deepen the grasp of personally comprehended and consolidated theory in some way. Know-how oriented engagements are still more sophisticated in that they add to the refinement-oriented types of engagements the additional aspect of making connections between disciplinary knowledge and real world situations. This progression in sophistication relates only to the nature of the engagement categories themselves; it does not intend to suggest that students necessarily study intentionally in such a linear and sequential fashion.

6.2 THEORY-FOCUSED STUDY PRACTICES

The outcome space presented in Table 6.1 describes the variation in the ways of experiencing and engaging in the study of theory that was evident among our students. Because practices are orientations that have developed from prior experience in particular kinds of activities (see the definition in section 3.10), the variation described in the table also describes the variation in orientations to engage in the study of theory in particular ways – i.e. it describes the variation in theory-focused study practice that was evident among our students. Accordingly, the table can be re-articulated in terms of practices rather than in terms of engagements. Before doing this however, the structural features of that variation are reviewed and discussed.

Table 6.1: Variation in Theory-Focused Study Engagements: The Outcome Space

Level	Category	Description	Knowledge type intended to be developed: + agency/resources used
1	Information oriented engagements	Study engagements oriented to learning facts, formulae, or information by assimilating, memorizing, or cramming[1] that information with no particular regard for its meaning or relevance.	Learned information: Resources used = texts[2]
2	Comprehension oriented engagements	Study engagements oriented to making sense of course material by reading through it, going through it, or working through it in order to develop personally comprehended theory with no particular regard for consolidating or restructuring the material as it is presented in the course.	Personally comprehended theory: Resources used = texts[2]
3	Consolidation oriented engagements	Study engagements oriented to consolidating or reinforcing personally comprehended theory by using consolidation tools such as highlighting, vocalizing, memorizing, summarizing, or applying theory in order to develop personally consolidated theory with no particular regard for refining it beyond the content or structure presented in the course.	Personally consolidated theory: Resources used = texts[2], and consolidation tools
4	Refinement oriented engagements	Study engagements oriented to deepening personal mastery of consolidated theory by refining it using refinement tools that restructure and make new connections by means of techniques such as elaborating, self-questioning, restructuring notes, concept maps, or visualizing in order to develop a personally refined grasp of disciplinary knowledge with no particular regard for how these relate to real world situations.	Personally refined theory: Resources used = texts[2], consolidation and refinement tools
5	Know-how oriented engagements	Study engagements oriented to deepening personal mastery of disciplinary knowledge by relating it to real world situations in order, implicitly or explicitly, to develop practical know-how.	Personally developed disciplinary know-how: Resources used = as above plus relevant real-world knowledge

[1] Cramming is a test-focused, reproduction-oriented study practice but it uses strategies similar to assimilating.
[2] Texts consist of course material contained in textbooks, class hand-outs, or notes taken in class.

The first structural feature of the outcome space described in the table is the set of characteristics that distinguish one category of practice from another. The most definitive characteristic is the 'type of knowledge' and five types were identified: learned information; comprehended, consolidated or refined theory; and practical know-how. A student's conception of the type of knowledge to be learned shapes the intention behind the study practice – i.e. a particular practice intends towards the development of one of these types of knowledge by using a particular kind of strategy, 'tool' or resource which a student perceives is appropriate to that intention.

The second structural feature evident in the categories of practice is that they form a hierarchy; i.e. one category presupposes the outcome of engagements in the previous category in the hierarchy. Comprehension-oriented engagements work with learned information to develop comprehended theory. Consolidation-oriented engagements work with comprehended theory to develop consolidated theory. Refinement-oriented engagements work with consolidated theory to develop a refined grasp of disciplinary

knowledge and know-how oriented engagements work with refined disciplinary knowledge to develop practical know-how.

A third structural feature has to do with the relationship between the categories of practice and the level of understanding which they afford. The hierarchy of categories constitute a progression that involves an increase in the sense made of information and theory, and in the degree of consolidation, integration, and refinement of understanding and its relatedness to the real world. In effect, the progression in the sophistication of a study practice and the progression in the depth of understandings afforded correspond. What this means is that the phenomenographic analysis has managed to identify a variation in the ways in which the students study that relates to a progression through different layers or depths of understanding. What is particularly significant about the way it has done this is that the thorny issue of how to describe unequivocally different levels of understanding has been avoided by anchoring the definition of the categories of variation in more tangible features, namely, the strategies and resources used by the study practices.

The relationship between quality of practice and the quality of learning which a practice affords can be viewed from a different perspective, i.e. from the perspective of the constraints on learning that are inherent in a student's learning practice. Each category of practice is associated with the development of the level of understanding associated with a certain type of knowledge (learned information; comprehended, consolidated or refined theory; or practical know-how). In principle, each study practice also constrains learning in that it does not inherently afford the development of the levels of understanding associated with more sophisticated study practices. This means that the transition from a lower category of study practice to the next higher category constitutes a threshold into a practice that, in principle, affords a deeper level of understanding. Accordingly, the sequence of five categories of study practice defines four such thresholds. In addition, three additional thresholds can be identified by examining the nature of the sub-practices in comprehension- and consolidation-oriented study practices. The first is evident between the comprehension-oriented sub-practices of 'going through' and 'working through'. Here, the level of understanding which a student develops by repetitive reading of texts (going through them) is likely not to be as deep as the level reached by a more methodical and careful 'working through' of that material. A second and a third threshold are evident between the consolidation-oriented sub-practices of 'memorizing' and 'summarizing' and between 'summarizing' and 'applying'. In these cases, the level of understanding associated with the reinforcement provided by practices such as 'vocalizing' and 'memorizing' is likely to be less than that achieved by thoughtful engagement with the theory to develop meaningful summaries. This, in turn, is likely to develop a level of understanding that is not as deep as the level to be expected from the sub-practice of 'applying' – that is, when a student intentionally engages with theory application problems for the specific purpose of deepening their understanding of the theory.

An important qualification with regard to constraints on learning must be highlighted at this point. The qualification is that a constraint is different from a limitation. I have argued that a study practice

constrains learning in that it does not inherently facilitate the development of the deeper levels of understanding associated with more sophisticated study practices. However, it does not necessarily *limit* or *prevent* the development of those deeper levels of understanding. For example, an intriguing presentation of a piece of theory or the way a teacher has modelled its application may inspire a student in the moment to engage in studying and learning in a way that transcends the current level of their learning practice.

Having discussed the various structural features of variation in theory-focused study practice, the associated outcome space is presented as Table 6.2. This is Table 6.1 re-articulated in terms of practices rather than in terms of engagements and includes the seven constraints thresholds just described. These are indicated as circled numbers in the table to show where in the hierarchy of study practices the constraint thresholds occur. (A fold-out copy of the table can be found in Appendix B, page 184.)

Table 6.2: Variation in Theory-Focused Study Practice: The Outcome Space

	Category	Description	Strategies Used and Thresholds*	Knowledge type intended to be developed: [Resources used]
1	Information oriented practices	Oriented to learning facts, formulae, or information by assimilating, memorizing, or cramming that information with no particular regard for its meaning or relevance.	Assimilating Memorizing Cramming 1	Learned information: [Texts]
2	Comprehension oriented practices	Oriented to making sense of course material by reading through it, going through it, or working through it in order to develop personally comprehended theory with no particular regard for consolidating or restructuring the material as it is presented in the course.	Reading through Going through 2 Working through 3	Personally comprehended theory: [Texts]
3	Consolidation oriented practices	Oriented to consolidating or reinforcing personally comprehended theory by using consolidation tools such as highlighting, vocalizing, memorizing, summarizing, or working problems in order to develop personally consolidated theory with no particular regard for refining it beyond the content or structure presented in the course.	Highlighting Vocalizing Memorizing 4 Summarizing 5 Applying	Personally consolidated theory: [Consolidation tools and texts]
4	Refinement oriented practices	Oriented to deepening personal mastery of consolidated theory by refining it using refinement tools that restructure it and make new connections by means of techniques such as elaborating, self-questioning, restructuring notes, concept maps, or visualizing in order to develop a personally refined grasp of disciplinary knowledge with no particular regard for how these relate to real world situations.	6 Restructuring Making connections	Personally refined theory: [Consolidation and refinement tools and texts]
5	Know-how oriented practices	Oriented to deepening personal mastery of disciplinary knowledge by relating it to real world situations in order, implicitly or explicitly, to develop practical know-how.	7 Relating	Personally developed disciplinary know-how: [the above plus real-world knowledge]

* Thresholds associated with constraints on learning are indicated by the dashed lines and circled numbers

6.3 TWO IMPLICATIONS OF THE OUTCOME SPACE

The implications of the findings of the phenomenographic study just described are discussed in Chapter 11 along with the implications of other findings from this study. However, two implications stand out immediately and are discussed here. The first is that a method for characterizing the theory-focused study practice (singular) of individual students emerges from the findings. The second is that the outcome space in Table 6.2 suggests a very direct linkage between the quality of a student's learning practice and the quality of their learning.

6.3.1 Characterizing the learning practice of individual students

It is very clear from the student interviews that individual students exercised a variety of theory-focused study practices. Clearly, individuals possess a suite of practices, and possibly also composites of several practices conflated together. However, because a practice at a higher level in the hierarchy of theory-focused study practices implies possession of the practices lower down in the hierarchy, it is possible to characterize a student's theory-focused study practice simply by identifying the most sophisticated practice in their repertoire. For example, some students, on entry to university, did not appear to exercise any study practice more sophisticated than comprehension-oriented practice. Accordingly, their study practice could be described as having reached only to the level of comprehension-oriented study practice; it included practices only at the levels of information- and comprehension-oriented practices. Eleven students were identified as having a study practice of this kind.

In a similar way, a study practice could be characterized as 'consolidation-oriented practice' if its most sophisticated practice was at the level of consolidation-oriented study practice. Study practice at that level presupposed some kind of comprehension-oriented practice which, in turn, pre-supposed at least the information-oriented study practice of assimilating information. Nine of the students were identified as having this type of study practice.

On the same basis, it was concluded that four of the students in the study entered university with a refinement-oriented study practice – their practice included some information-, comprehension-, consolidation- and refinement-oriented practices. In addition, it appeared that three of the students entered university with elements of know-how oriented study practice (specifically, a well-established disposition to relate understandings to real world situations) and also practices from the other four categories of study practice.

Only in two cases, students E and O, did this characterization scheme give an inaccurate impression of a student's study practice. Both students possessed reasonably sophisticated learning practices but, because of self-confessed laziness and because studying was not a dominant priority for them, they tended to exercise primarily their less sophisticated study practices.

6.3.2 The linkage between quality of study practice and quality of learning

The finding that the categories of study practice correspond with increasingly deeper levels of understanding has profound implications. It implies that the type of study practice which a student has developed may constrain their learning in very specific ways that can be explained by reference to the categories of variation that have been described here.

To explore this idea further, it can be argued from the conceptual framework of practices developed in Chapter 3 that practices provide affordances as well as constraints. They facilitate execution efficiency in that they provide a degree of automaticity that enhances the efficient execution of an activity. However, that enhanced efficiency is restricted to the range of activities associated with the practice so that a student who relies on their current study practice – 'they just do what they do' – will inherently be restricted to employing only those practices which they have developed from their prior experience. Accordingly, for example, a student having a comprehension-oriented study practice does not have the experience of or leaning towards studying in any way other than by means of practices in the suites that are associated with information- or comprehension-oriented study practices. Similarly, a student manifesting a consolidation-oriented study practice does not have experience of or leaning towards studying except by means of the suite of practices associated with information-, comprehension- and consolidation-oriented study practice. Further, a student with a refinement-oriented study practice has the experience and leaning to engage with the full range of study practices mentioned except that of routinely thinking about real world situations and relating their knowledge and skill to the world.

When this observation is considered in conjunction with the observation that the different categories of study practice are associated with the attainment of different levels of understanding, the implication is that the level of understanding a student is likely to achieve is constrained by their study practice in a rather detailed way. If, for example, a student has developed their study practice only to the level of comprehension-oriented practice they are unlikely, routinely and intentionally, to develop personally consolidated theory; a student with a consolidation-oriented study practice is unlikely to routinely develop personally refined disciplinary knowledge and a student with a refinement-oriented study practice is unlikely to routinely lift their level of understanding to that of practical know-how by routinely relating their knowledge to real world situations.

6.3.3 A test of the linkage between study practice and quality of learning

Data on the academic performance of the students (i.e. the grades they achieved) enabled a rough test of the proposition that the type of study practice used constrains the level of understanding achieved. It is acknowledged that reference to grades as an indication of understanding attained, though convenient, is not altogether satisfactory. It is convenient because the information is readily available (and it was the only independent data available in this study) and it has some merit as an indicator of the level of understanding attained because tests, assignments and examinations at university are intended to assess understanding. However, other factors affect performance in such assessments – for example, language difficulties, test-

taking competencies, difficulties in transitioning to university, the impact of other learning practices, and the nature of assessment strategies.

Despite this, grades were used in this part of the analysis to get a rough indication of whether any correspondence was evident between the type of study practice employed and the level of understanding attained. The selection of which set of grades should be used for this indication was done on the following basis. Aggregate marks from school leaving examinations were not considered because of uncertainties about what they indicated – in particular the extent to which they tested understanding as opposed to rote learning ability. Therefore, grades obtained at university were used. In addition, only first semester grades rather than year end grades were used because they were more closely related to the students' study practices on entry to university.

Grades from the course 'Introduction to process and materials engineering' were selected in preference to an overall grade or grades in other first year subjects. The reason was that the 'Introduction to process' course involved completely new material for all the students in the cohort. The other major courses in the first year programme – maths, physics and chemistry – involved some degree of revisiting of conceptual material covered at school and so students' performance in the mid-year tests could be influenced by factors other than the understandings developed at university; in particular it could be influenced by the quality of the schooling they had experienced.

On this basis the information in Table 6.3 was generated. The table considers students in four groupings defined according to the level of sophistication of study practice on entry. The table also indicates how the students in each grouping performed academically. Taking the performance level achieved as an indication of the level of understanding attained when studying, the most sophisticated study practice (level 5) was associated with the highest level of understanding followed by the next most sophisticated practice – refinement-oriented practice. The understandings attained by students with less sophisticated practices were clearly much poorer. Comprehension- and consolidation-oriented study practices were associated with similar levels of understanding, as suggested by the mid-year grades, with the understandings from consolidation-oriented practice perhaps being marginally deeper.

(The text continues after the table.)

Table 6.3: Theory-Focused Study Practice on Entry vs Level of Performance at Mid-Year

	NUMBER OF STUDENTS AT EACH LEVEL OF ACADEMIC PERFORMANCE (Percentage of students with the same level of study practice who perform at the levels of academic performance indicated.)					
Level of performance → **Level of Study Practice on entry ↓**	**Fail < 45 %**	**Borderline Fail 45-50%**	**Borderline Pass 50-55%**	**Good Pass 55-70%**	**Excellent Pass > 70%**	***Totals***
Level 2: Included information- & comprehension-oriented study practices.	3 (27%)*	4 (36%)*	3 (27%)*	1 (9%)*	0	*11*
Level 3: Included the above plus some consolidation-oriented study practices.	2 (22%)*	3 (33%)*	3 (33%)*	1 (11%)*	0	*9*
Level 4: Included the above plus some refinement-oriented study practices.	0	0	0	3 (75%)*	1 (25%)*	*4*
Level 5: Included the above plus some know-how oriented study practices.	0	0	0	0	3 (100%)*	*3*
Totals	*5*	*7*	*6*	*5*	*4*	*27***

* The percentage refers only to students in the same row – i.e. having the same level of theory-focused study practice.

** Note: Data from 4 students has not been included in the table for the following reasons. One student left before completing the first semester, the practice of two could not be easily characterized (because of inappropriate study prioritizations), and the data from one student was discarded as being unreliable.

Because of the problematic association between academic grades and the level of understanding achieved (and also because of the small number of students involved), not too much can be concluded from findings derived from the information presented in Table 6.3. What can be claimed is general support for the proposition that the level of understanding a student attains when studying is constrained by the level of sophistication of their study practice as defined by the five categories of theory-focused study practice.

6.4 SUMMARY

In this chapter, 5 categories of qualitatively different theory-focused study engagements were identified from the analysis of the relevant transcript data. Each is characterized by the type of knowledge the engagement intends to develop, by the type of engagement strategies it employs and by the type of resources or tools which those strategies utilize. These types of engagement are recognized to be the manifestation of five types of qualitatively different study practices as presented in Table 6.2. The categories form a hierarchy of increasing sophistication with each building on the outcomes of engagements in lower level categories and each associated, in principle, with the development of a deeper level of understanding of the material studied. As such, the study practice (singular) of individual students – the pattern of study practices they possess and manifest – can be characterized in terms of the most sophisticated category of study practice they manifest, practices at a lower level of sophistication being pre-supposed.

The outcome space from the phenomenographic analysis suggests that the level of understanding which a student might attain when studying is constrained by their practice and some limited empirical endorsement of this finding was found. Finally, the transition from one level of study practice to another was recognized as constituting a threshold into a level of practice that, in principle, opens up the possibility of attaining deeper levels of understanding of the material being studied. Seven such thresholds were identified including three among the sub-practices associated with comprehension- and consolidation-oriented practices.

The chapter which follows presents findings of the study in regard to another type of learning practice which is closely related to theory-focused study practice, namely problem-focused study practice.

CHAPTER 7: DATA ANALYSIS AND RESULTS 2: THE VARIATION IN PROBLEM-FOCUSED STUDY PRACTICE

This results chapter, the second of five, presents the analyses and findings related to problem-focused study practices – practices that involve calculations and problem solving. As stated in section 5.3, the term 'problem' is taken to mean *a question or difficulty that cannot be resolved without some kind of numerical or mathematical manipulation*. Maths, science and engineering courses typically require students to solve problems and typically assess students by means of problems – sometimes exclusively so. Consequently, the ways in which engineering students go about studying, learning from and engaging with problems are critically important constituents of their learning practices.

It was evident from the initial examination of the transcripts that study engagements which focused on the solving of problems were quite different from theory-focused study engagements (the type of engagement investigated in the previous chapter). One involves the exercise and development of a skill – problem-solving skill – while the other involves the further development of knowledge. One is focused on difficulties needing to be resolved while the other is focused on engaging with and understanding course material. Despite these differences, problem-focused study engagements were clearly closely related to theory-focused study engagements; working problems requires knowledge developed from theory and the learning of theory is facilitated, at least in part, by working through problems. This association is addressed in much more detail in the next chapter. This chapter focuses only on the nature and variation in the students' problem-focused study practice.

7.1 THE STUDENTS' EXPERIENCE OF PROBLEMS

Examination of the transcript fragments which related to engaging with problems showed that the students experienced 'problems' in three different ways: as an examinable feature of a course; as problem-solving tasks; and as a means of checking and enhancing their understanding of theory.

Problems as an examinable feature of a course

The fact that, in almost all of the students' courses, problems were a major component of assessments meant that the students' experience of problems was inter-related with their experience of preparing for tests and examinations. Chapter 9 addresses the issues and practices related to preparing for tests/exams and so this aspect of the students' experience of problems will not be discussed in this chapter.

Problems as problem-solving tasks

This aspect of the students' experience of 'problems' was that they were one kind of task among several other kinds in a course and involved engaging with and solving a large number of 'problems' related to the content of the course. In these problem-focused engagements, the issues of assessment and of enhancing theoretical understandings were very much in the background because students were concentrating on the

specifics of solving the problems they were working on. It is this type of engagement that is the focus of this chapter.

Problems as a means of enhancing the understanding of theory
This aspect of the students' experience of 'problems' has already received some attention as the consolidation-oriented study practice of 'applying' theory (section 6.1.3). As already mentioned, the issue of the integration of the solving of problems and the learning of theory is addressed more fully in the next chapter.

7.2 VARIATION IN THE STUDENTS' ENGAGEMENTS WITH PROBLEM-SOLVING TASKS

From the interview data it was evident that students engaged with problem-solving tasks in various ways and with various intentions. Five categories of problem engagements were identified. These are distinguished on the basis of four factors: task-type, problem-type, skill-type, and strategy-type. The nature of these factors and how they inter-relate in the characterization of the different ways in which students related to engaging with 'problems' is set out below in principle and then, after that, is explained in more detail in the descriptions of each category.

7.2.1 The factors characterizing the categories of variation

There was some variation in the way students experienced 'problems' as problem-solving tasks and this variation can be described in terms of four *task-types*; familiarization tasks, calculation tasks, theory-application tasks, and skill-development tasks. Fuller explanations of these types are given in the sections that follow.

Students had different conceptions about the types of problems they encountered but they articulated their conceptions in only vague terms: i.e. easy or difficult problems, example problems in textbooks, problems with solutions, problems with answers or no answers, or problems from past papers. Some statements hinted at recognizing problems as being associated with problem solving as an independent skill [Student AA] and some hinted at seeing them as having to do with the application of theory for the resolution of real-world problems. During the analysis, it became apparent that five qualitatively different conceptions of the nature of a problem – the type of problem it is – existed among the students and that these exerted a strong, albeit implicit, influence on how students related to and engaged with the problems they typically encountered. The five conceptions of *problem-type* are: worked-examples; formula-application problems; theory-application problems; complex problems; and world-application problems. These are discussed and explained in more detail in the sections which follow.

The intentions driving the students' engagements with problems went deeper than the desire to simply solve them and get correct answers although, superficially, this was the most obvious intention. Students were aware, however, even if only implicitly, that the intention behind tackling problems in their times of study was to develop the ability or skill to solve unseen problems that were somewhat similar in kind,

although not in detail, to the problems they were tackling. Implicitly, therefore, the variation in conceptions about the nature of problems translates into a variation in the types of skill students were aiming to develop by engaging with those problems. For example, if students conceived of problems as being theory-application problems – problems that required and provided experience of the application of theory – then the intention of engaging with problems was to develop the skill of solving problems of that type or, put differently, to develop theory-application skill. Therefore, corresponding to the above five problem-types are five *skill-types*. These have been labelled respectively, procedural knowledge/skill, formula-application skill, theory-application skill, heuristic problem-solving skill, and world-application skill. The nature of these and the rationale behind the descriptors used is given in the sections which follow.

To tackle a problem-solving task by engaging with a problem requires the utilization of an engagement strategy and that strategy is selected, implicitly or explicitly, because it is conceived that it will develop the kind of problem-solving skill desired. Four types of strategies – *strategy-types* – were used by students to develop problem-solving skills: studying worked-examples, 'practicing problems', reflecting on methods, and reflecting on relevance. By far the most widely employed of these was practicing problems and so it is discussed below in a little more detail. The other strategy-types are discussed and explained in the sections that follow.

'Practicing problems' ('working problems' or 'doing problems') involves working on a sufficient number of problems to develop a degree of familiarity and skill at solving problems of the kind attempted. Some students explained the strategy in the following terms: "I just practised, I just took past papers and I just practised and practised and practised. That's all I did" [S/1]; "I just practised questions … do them, and it sort of sinks in" [E/1]; "after quite some time you get to the hang of it" [J/1], and "practice makes perfect" [K/1]. As will become evident, 'practicing problems' was a generic strategy used in most of the categories of problem-focused study engagements.

The five categories of problem-focused study engagements identified in the phenomenographic analysis are listed below. Each is discussed in detail in the sections that follow. Thereafter, equivalent categories of practice are described.

Familiarization-oriented problem engagements
Formula-application-oriented problem engagements
Theory-application-oriented problem engagements
Heuristic problem-solving-oriented problem engagements
World-application-oriented problem engagements

7.2.2 Familiarization-oriented problem engagements

The course material presented to students included many 'worked-examples' – example problems with accompanying solutions and answers. In addition, students worked out their own solutions to problems during the year and probably engaged with these as worked-examples when preparing for tests or when

reviewing their work. No student mentioned doing this specifically but it remains a highly likely probability. Either way, students engaged with many worked-examples during their courses.

Very obviously, to engage with worked-examples is quite different in nature from engaging with problems presented without solutions. Accordingly, a worked-example was experienced by students in a different way from other types of problem and so the analysis recognized '*worked-examples*' as a distinct type of 'problem'. How students engaged with such 'problems' is illustrated by the following extracts from student M.

> *How did you go about learning maths?* Study. I studied it like … read the solution, read the solution through, cram like when you have [understood that procedure]. [M/1]
>
> *Did you have examples in those notes?* Yes, we did. *To what extent were those important for you in your understanding of the theory?* They were important because I did go do them as notes. Like I did everything, as I say, and I read everything, notes, examples, until I'm satisfied that I know and then I attempt the problems. [M/1]

As the above extracts indicate, the task of engaging with worked-examples is perceived as a *familiarisation task* – students study the examples for the purpose of becoming familiar with how to solve problems like them. The strategy is to *study worked-examples* and to do so prior to the serious business of attempting unseen problems. The type of skill which the strategy intends to develop is not easy to explain succinctly. It is perhaps best described as *procedural knowledge* and conditional knowledge (Biggs, 2003). It consists of familiarity with typical procedural connections and the conditions associated with those connections and the ability to develop solutions based upon such knowledge. As Student M put it "you … do this when you have that … do this, ok, step one, if you have something like this you … can do this, the next step is this and then this" [M/1].

At least one student (student M) studied the worked-examples "as notes" and, in her case, worked hard to memorize the procedures ("not as in 'cram' but store [sic]"). Previous extracts from this student's transcripts (see section 6.1.3) indicate, as here, that 'memorization with understanding' was a strong feature of her study practice.

From the above discussions, two qualitatively different ways of engaging with problems are evident. They are labelled 'familiarization-oriented problem engagement' and 'memorization-oriented problem engagement'. The former is a generic first step in the development of procedural knowledge that probably all students used when they began to tackle problems. The second is similar in nature except that there is a distinct intention to memorize procedures. As such, it is recognized as a subcategory of familiarization-oriented problem engagements. In some cases, remembered solutions or solution procedures were intentionally recalled when engaging with unseen problems. This is illustrated in the following extract.

> I just try to understand the question and what's actually going on, compare it to maybe something that I've already read through the textbook, for an example that I've seen in the text book. *In your mind compare it?* Yes. [R/2]

7.2.3 Formula-application-oriented problem engagements

One way in which students experienced 'problems' was as being of the kind that can be resolved by applying and manipulating the appropriate formula, algorithm or standard procedure – "I understood the

basics, and then it's just the procedure" [B/1]. "Those problems [the easier ones] were the ones where you put in your formula" [H/1]. In effect, the conception here is that the problem is a *formula-application problem* and the task is a straightforward *calculation task.* The following extracts describe two examples of formula-application problem-types. The first relates to an approach to problem-solving that was widely reported by students in the context of using formulae in science subjects – the type of 'plug and chug' process of substituting numerical values into a formula and calculating a result.

> If I have a certain formula … I'll take that and then whenever I get a sum I'll look for anything that's missing in the formula. Like I'd look at the formula, let's say pressure is missing, I'll look for it [the value of the pressure], if I don't get it then I'll automatically think, ok, that's what we're supposed to get [calculate] and I just try everything to get the pressure. But I wouldn't actually think about, OK, what if maybe the temperature would actually affect it …something that's usually out of the norm. [S/1]

The second example relates to formatting and calculation procedures in the school subject of accounting.

> *So how did you learn for accounting?* … I used to just get the formulas and everything and …because they give you the format … of the balance sheet, you have to know it and there's like specific calculations for everything. It doesn't change. You don't have to think out the box for accounting. *To what extent did you actually understood the method and the material?* Mmm…I'd say I did, to a certain extent …. because I liked it so much, I used to go through everything and I had such a broad understanding of it. [S/1]

As the above extracts indicate, in this category of problem-focused engagements, a student is aware that the type of skill needed for solving formula-application problems involves knowing the standard procedures and being practiced in executing them. This type of skill is labelled *formula-application skill.* Implicit in the above extracts is the recognition that, to develop this type of skill, requires two strategies – first *studying worked-examples* to gain familiarity with the procedures and then *practicing problems*.

While the manipulation of scientific formulae and the use of standard calculation procedures are valid methods for manipulating or calculating numerical information – that is, they can be utilized 'meaningfully' as evident especially in the second extract above – they can also be used somewhat 'mindlessly' and without any real understanding as illustrated in the following extracts. The second extract illustrates the view that "you don't really have to think" when manipulating algorithms mechanically.

> At school, sometimes I didn't know what was I doing. All I knew was the equations [formulae] and I knew that this number goes into this [variable] and with this information that I got, I can calculate this. That's it. I didn't know actually what was happening exactly. [K/1]

> I think when you're just given the formula, which is what happens in high school, you didn't really have to think. I don't know if other people will see it this way, but for me that's how I viewed it. And I think that's what made high school very easy – that you didn't really have to think. You're given the formulas and … this is the length this is the breadth, whatever, and there is the formula. [A/1]

The next extract denigrates the use of formula-application skill if it is the *only* problem-solving skill utilized: "*<u>Just</u>* plugging in formulas and expecting it to work out … [that] doesn't work" [H/1]. What is apparent from these three extracts is that if a student's conception of problems is limited to seeing them as formula-application problems then the development of their problem-solving skills is likely to be constrained to the development of formula-application skills.

7.2.4 Theory-application-oriented problem engagement

This category of problem engagements is one in which students do more than simply apply the relevant formula; they try to analyse the situation and exercise thought in trying to understand what is going on in order to work out a solution to a problem. This is well illustrated in the following extracts.

> You have to analyse them [the problems] and know what's happening. … they are checking your understanding, you see. So if you don't understand but … you know the formula [and can only use formula-application methods] … you will struggle. [I/2]

> I think if I [work only on] my question paper I'm just only going to know how to answer the question paper and not understand exactly what I'm doing there. That's why I first read everything, try the examples in the text book, then [attempt problems]. [R/1]

Evident in these extracts, especially the first one, is the conception that the problems presented to students provide the opportunity to develop or deepen their ability to apply theory in order to solve problems – the problems "are checking your understanding" of theory and of how to apply it; in other words the skill being developed is *theory-application skill*. As such problems are being conceived as *theory application problems* and to engage with such problems is to tackle *theory-application tasks.*

With regard to the students' awareness about the strategies to use to develop theory-application skill, it is evident from the above extracts, especially the second one, that there is a need to first *understand the theory*; then to familiarize oneself with how that theory is applied; and thereafter to practice solving many relevant problems. In effect, several strategies need to be used in combination. However, missing from this list of strategies is any sense of the need to reflect on and improve one's 'heuristic problem-solving skill' which is the defining characteristic of the next category of problem-focused study engagements. Instead, the conception is that the skill of being able to solve theory application problems will somehow develop as a result of practicing enough problems.

7.2.5 Heuristic problem-solving-oriented problem engagement

In this category of problem-focused engagements a student intentionally pays attention to the heuristics of problem solving; they reflect on the problem-solving processes of, for example, analysing problems, breaking them down into manageable pieces, finding meaningful connections between the available data, and synthesizing solutions. This contrasts with the previous category where, although a student is undoubtedly analysing problems, connecting data and synthesizing solutions etc., they do so rather implicitly and do not intentionally reflect on the nature and effectiveness of these processes. The next four extracts give examples of the kind of heuristic reflection that characterizes this category of problem engagements.

Looking at underlying issues and the solution logic:

> When I work with problems I try to understand all the underlying issues. Why is this taking me to that? Why is that taking me to that – back and forth. But most of the time I just tried to answer what's the logic behind something. [D/1]

Breaking down problems

> How do I study maths? … I'd read my textbook; see how the textbook breaks down that question. [F/1]

Carefully studying the solution methods in worked-examples

> I checked there, the textbook which had …lots of examples…. when it …explained the method … to solve the problems, they illustrate in the example and from the example I can… understand… more better. [AD/2]

Awareness of problems as skill-development tasks; development of heuristics and of confidence:

> [The problem] is also testing problem solving. ... Because if you come across something particularly difficult or that you can't do in the 'applied problem' [given in the tutorial] and you ask for help… and it's explained to you, then you sort of learn from that and think, ok… when stuck like this do this… or when I get stuck don't panic I can always figure something out. [AA/2]

The last extract (student AA) is particularly interesting because it draws attention to a number of qualitative differences between this category and the previous one. The first is that there is an implicit awareness of 'problem-solving' as a relatively independent skill that transcends the specifics of particular theory application problems. In other words, there is a shift in the conception of the skill type which problem engagements should aim to develop – ie from theory-application skill to heuristic problem-solving skill.

The second difference follows from this; problem-solving tasks are now implicitly conceived to be *skill-development tasks* because the purpose of engaging with problems is now seen to be the development of problem-solving skills. This is a more advanced conception than that of theory-application tasks but includes it; problem-solving skills are additional to theory-application skills, they do not supplant them, and very much depend on them.

A third difference is a shift in the suite of strategies that are needed to develop problem-solving skills. The category of problem-solving engagements requires all the strategies associated with theory-application problem engagements – understanding theory, studying worked-examples, and practicing problems – but it also, importantly, utilizes the strategy of *reflecting on solution methods* as explained at the beginning of this section.

The fourth difference between the two categories is more subtle and requires some explanation. This category of problem engagements comes into its own when the problems being solved are complex – for example, when they have multiple aspects each of which constitutes a theory-application problem in its own right. In such problems situations, theory-application skill (the ability to solve a theory application problem) must inherently struggle to develop a solution unless it is combined with good problem-solving heuristics; without this, an efficient and effective way of solving the theory-application problems embedded in the complex problem must be inherently difficult to develop. Accordingly, this category of problem engagements conceives problems as being *complex problems*.

However, there is a more fundamental reason for this conception. It derives from the implicit consequence of reflecting on the heuristics of solving problems in that such reflection brings into focus two sets of dynamics that are occurring together: the dynamics associated with thinking about how theory needs to be applied to solve a problem; and the dynamics associated with working out the heuristics for solving that problem. The first set of dynamics is the same as that associated with solving theory-application problems.

The second set of dynamics looks past the application of theory and views problems as a kind of network of inter-connected data and associations that needs to be understood and untangled heuristically. In other words, to reflect on the heuristics of problem-solving processes is to see problems as being inherently complex in nature.

In summary, the defining characteristic of heuristic problem-solving-oriented engagements is that they involve an additional strategy type – reflecting on methods. A student who relates to problems in this way, implicitly views problem-solving tasks as skill-development tasks and problems as complex problems. In addition, such a student has an implicit conception that the skill-type that needs to be developed is problem-solving skill and that what is needed to develop that skill includes 'reflecting on methods' combined with all the strategy-types that have been mentioned.

7.2.6 World-application-oriented problem engagement

In this category, problems are seen as questions or difficulties arising from real world situations and are tackled for the purpose of gaining further insight into some aspect of what is happening in the world. From this perspective, problems are '*world-application problems*' in that theory and problem-solving processes are applied to the solving of a problem related to or derived from the real world; all aspects of solving the problem – the application of theory, the formulation of the problem in terms of that theory, and the solving of the problem so formulated – are oriented to or applied to the resolution of some difficulty in the real world.

This is an advanced conception of the nature of problems. While none of the students related fully to problems in this way, there were some indications with a few of the students that they had a 'world-oriented disposition' in that they were dispositionally oriented to thinking about how problems, or aspects of them, related to real world situations. This is demonstrated in the following extracts. The first illustrates the disposition of wanting to see the real world application when using theory, while the second demonstrates how one student's interest in science derived from the conception that theory can be applied practically to engage with real world situations.

> For me definitely the application is very important. I have to see how it works, if it works… and where it works … in order to understand it better. [AA/2]

> I just loved the theory and the practicality behind it. Like the fact that you could learn theory and then apply it to everything. Just pretty much be able to apply it to anything. Like laws that things are governed by. Just really interesting. ... My grade 11 and matric science teacher just really got me grasped on it, just the way she would explain it, the way she would lead you into it, the examples she would give you and where it would apply, and just generally things like that, and when we started doing experiments and [practicals] it just really grabbed my interest. [C/1-6]

Relating to problems as world-application problems, even if only dispositionally, adds an extra dimension to the way students engaged with problems; specifically, it leads to reflecting on how the problem and/or its parts are relevant to real world situations; this strategy type is labelled '*reflecting on relevance*'. The following extracts illustrate this type of strategy; the student talks about "learning to apply to different cases" and reflects on issues such as flaws or difficulties in how the theory is applied, and what must be considered when applying the theory to realistic situations.

> *What made you successful in the way you learned chemistry and physics?* I think it's just…having learned something and taking … what you learned and learning to apply it to various different cases. And if you can do that it means you've actually fully understood the concept if you can apply it. That's what I felt. If you find a new problem with the same theory over and over again…well, different problem but same theory, at the end you're quite confident with the theory itself. *So your confidence arose out of the fact that you applied it in different situations and it worked OK.* And always doing practice questions. I wouldn't just read a theory and understand it. I'd do a couple of questions to really see also where the flaws in it are or what are the difficulties? What must be considered? [E/1]

While the defining characteristic of this category of problem engagements is the strategy of '*reflecting on relevance*', it clearly cannot be the only strategy utilized but is additional to all the strategies associated with the previous category. This shift in strategy must also be associated with a shift in the intention behind problem engagements in this category, namely, a shift in the conception of the type of skill to be developed by engaging with problems. If problems are now conceived as world-application problems, then it follows that the skill needing to be developed in order to solve such problems is the skill at relating problems and its parts to real world situations when solving problems. This type of skill has been labelled '*world-application skill*'. In addition, problem-solving tasks that have the intention of developing this type of skill are conceived as being *skill-development tasks*.

7.3 THE VARIATION IN PROBLEM-FOCUSED STUDY PRACTICES

The general picture of how students related to the solving of problems when studying was as follows. They related to problems firstly as tasks in which they were required to solve the problems and, ideally, get the correct answers. At a deeper, usually implicit level, students related to problems with the intention of developing the kind of skill which they conceived was necessary for solving problems of the kind they were tackling. To act on this intention, students adopted particular strategies which they conceived as being appropriate to that task. The type of strategy selected depended on the students' conceptions of the kind of skill they wanted to develop. In turn, these conceptions were determined by the students' conceptions of the nature of problems in general and of the problem being tackled in particular. On the basis of this scenario, it was conceptions of the nature of problems that is the most fundamental factor shaping how students went about solving problems and, consequently was the primary characteristic used in defining the different categories of problem-focused study engagements.

Because practices are orientations to engage in activities in particular ways, the 5 categories of problem-focused study engagements identified in the previous section constitute 5 categories of problem-focused study practice. Consequently, the variation in the students' problem-focused study practices can be described in terms of these five categories. The categories are set out in Table 7.1 below along with a summary of the distinguishing features of each category. The structural features of this outcome space are discussed after the table. (To make reference to the table easier while reading the discussion, the reader may like to fold out the copy of Table 7.1 in Appendix B, page 185.)

Table 7.1: Variation in Problem-Focused Study Practices: The Outcome Space

	Category of Practice and Thresholds*	Description of Problem-Focused Study Practice	Distinguishing Features.
1	Familiarization practice	Oriented to engaging with worked-examples to develop or deepen the appropriate procedural knowledge and skill by means of studying the worked-examples carefully.	Task-type: *Familiarization task* Problem-type: *Worked-example* Skill-type: *Procedural knowledge/skill* Strategy-types: *Studying worked-examples*
	Memorization-oriented Practice (Subcategory of the above)	Oriented to engaging with worked-examples to develop or deepen the appropriate procedural knowledge by mean of studying the worked-examples carefully and committing them to memory.	Task-type: *Familiarization task* Problem-type: *Worked-example* Skill-type: *Procedural knowledge* Strategy-types: *Studying worked-examples* *Memorizing procedures*
2	8a Formula-application practice	Oriented to engaging with problems which are experienced as formula-application problems and engaging with these to develop or deepen formula-application skill by means of studying worked-examples and practicing problems.	Task-type: *Calculation task* Problem-type: *Formula-application problem* Skill-type: *Formula-application skill* Strategy-types: *Studying worked-examples* *Practicing problems*
3	8 Theory-application practice	Oriented to engaging with problems which are experienced as theory-application problems and engaging with these to develop or deepen theory-application skill by means of understanding theory, studying worked-examples, practicing problems, and, where appropriate, applying relevant formulae.	Task-type: *Theory-application task* Problem-type: *Theory-application problem* Skill-type: *Theory-application skill* Strategy-types: *Studying the theory* *Studying worked-examples* *Practicing problems*
4	9 Problem-solving practice	Oriented to engaging with problems which are experienced as complex problems and engaging with these to develop or deepen problem-solving skill by means of reflecting on solution methods in addition to strategies used for the previous category.	Task-type: *Skill-development task* Problem-type: *Complex problem* Skill-type: *Problem-solving skill* Strategy-types: *As for category 3* *Reflecting on methods*
5	World-application practice	Oriented to engaging with problems which are experienced as world-application problems and engaging with these to develop or deepen world-application skills by means of reflecting on relevance to real world application in addition to strategies used for the previous category.	Task-type: *Skill-development task* Problem-type: *World-application problem* Skill-type: *World-application skill* Strategy-types: *As for category 4* *Reflecting on relevance*

* Thresholds are indicated by the circled numbers and dotted lines.
The numbering of constraint threshold 8a is different from the rest because it is conceptually derived rather than having been specifically derived from student comments.

7.4 THE STRUCTURAL FEATURES OF THE OUTCOME SPACE

As indicated in the table, the variation in problem-focused study practices is characterized by variations in four factors: *task-type* – the conception of the nature of the problem-solving task; *problem-type* – the conception of the nature of problems; *skill-type* – the conception of the type of skill that needs to be developed in order to resolve problems of the type conceived; and *strategy-type* – the type of engagement strategy used to develop that skill-type.

The five categories of variation form a hierarchy of increasing sophistication and complexity from category 1 to 5. As was the case with the categories of theory-focused study practices (see section 6.2), more sophisticated categories presuppose and include the less sophisticated categories.

As before, a significant implication of the hierarchy of practice categories is that, in principle, the quality of a student's problem-solving activities is likely to be constrained in a very particular way by the level of their problem-solving practice. For example, if the problem-solving strategies a student typically employs depend on the conception of problems associated with the category of practice they have reached, it means that strategies associated with more sophisticated conceptions of problems are not readily accessible to them. Therefore, the transition from one category to the next higher constitutes a threshold that, in principle, constrains the quality of their problem-solving engagements.

Examination of the five categories highlighted three such constraint thresholds. They are indicated in Table 7.1 as dashed lines and circled numbers. Threshold 8a, between categories 1 and 2, relates to the constraint imposed by a practice of only studying worked-examples (category 1) as compared to attempting unseen problems (categories 2 and up). Threshold 8, between categories 2 and 3, relates to the constraint on learning imposed by only seeing problems as formula-application problems (category 2) as opposed to seeing them as problems that apply theory and require some thought (category 3). Threshold 9, between categories 3 and 4 (between theory-application and problem-solving practices), relates to the constraint imposed by a lack of reflective practice or, put differently, by the conception that problem-solving skill will somehow develop just by practicing enough problems.

Following the argument developed in section 6.3.1, the problem-focused study practice (singular) of individual students can, in principle, be characterized in terms of the most sophisticated category of problem-focused study practice they typically exercise. However, this characterization scheme did not prove to be very discriminating in the case of the students in this study; virtually all of them seemed to be functioning at level 3 (theory-application oriented practice) with some functioning partially at level 4 (problem-solving-oriented practice). A small number of students had dispositions associated with level 5 (world-application-oriented practice) but did not appear to function at that level. Ideally, students should be functioning at the level of heuristic problem-solving, i.e. level 4, if they are to perform well in the process engineering course and in the subsequent years of the degree programme.

CHAPTER CONCLUSION

The findings presented in this chapter and the previous one relate to two types of study practice that are exercised in the context of a commitment or disposition to engage with course material and problems with the intention of mastering the related knowledge, understanding and skill. Because both practices are usually exercised together in the same context, different students exercised them in different ways and in different combinations. The next chapter investigates this aspect of learning practices.

CHAPTER 8: DATA ANALYSIS AND RESULTS 3: THE VARIATION IN MASTERING-ORIENTED STUDY PRACTICE

This results chapter, the third of five, presents the findings of a conceptual development related to a meta-practice that involves theory- and problem-focused study practices functioning together. That meta-practice has been labelled mastering-oriented study practice (which is frequently abbreviated to 'mastering-practice').

The chapter begins with a consideration of the different ways in which students reported using theory- and problem-focused study practices together. From the findings of this analysis an argument is made that theory- and problem-focused study practices should not be considered in isolation from one another but as components of a meta-practice. The nature of that meta-practice and the variation in the ways it is exercised is then worked out conceptually. Thereafter, the structural details of that variation and the implications of those details are examined and their impact on student learning is discussed. An argument is then made that the meta-practice – mastering-practice – plays a crucial role in shaping the quality of student learning. Some empirical evidence is presented in support of this argument.

8.1 THE RELATION BETWEEN THEORY- AND PROBLEM-FOCUSED STUDY

As discussed in detail in Chapter 6 and 7, all students reported that they exercised both theory-focused and problem-focused study practices when attempting to master their courses. They focused on learning theory independently of solving problems and also as a prerequisite for solving them. They solved problems because it was a requirement of the course and to develop problem-solving skill. They also solved problems as a means of enhancing the learning of theory, a practice that has already been recognized as the consolidation-oriented study practice of *applying* theory. In this section, the evidence with regard to how the two types of practice were exercised together is discussed.

There was some variation in the way that theory was consulted when tackling problems. Some students seem to have relied on what they had grasped of theory from classroom input and, when it came to homework or study, dived straight into calculations and problem-solving without any explicit reference to theory. This was especially common in the subject of mathematics as the following extracts illustrate.

> Maths I just practised questions. And you always find new questions, you do them, and it sort of sinks in. And then I always try to find more difficult questions than the standard you get in the exam. So if you know you can solve those, the other ones you're going to do fast. So that's what I try to do in maths. [E/1]

> With my maths I did question papers, there were lots of them. So I didn't even use my book. I don't know if it got lost along the way because I didn't use it. All I used was the question papers. Ok, for physics sometimes I had to refer to my notes, and then do the actual question papers. I only know it was question papers. [K/1]

The second extract demonstrates a fairly widespread conception, explicit in the students' statements or implicit in their study practice, that maths practice is more important than maths theory – a sentiment articulated particularly clearly by student V.

> *How did it affect the way you solved the [maths] problems if you didn't understand the theory that well?* It didn't that much. It didn't affect the way I solved the problems. Because sometimes in maths you don't need theory, you just…sometimes there is theory you need to know, but it didn't really affect. [V/1]

In science subjects, on the other hand, there was a general recognition that you cannot solve the problems without an adequate grounding in theory. The following extract illustrates the common practice, when engaging with science problems, of focusing first on theory, then studying worked examples to see how the theory was applied in solving problems, and then working on problems to develop the problem-solving skill related to the theory learned.

> Physics was a mixture. *How did you learn the theory in physics? …* OK, before I actually even attempted questions I would first understand the theory, do a couple of examples, and then tackle the questions. *So you studied the theory, a couple of questions, and…* It's theory, example, and then I look for [unseen problems] … If I …. was studying momentum, I study the theorem of momentum, do an example on momentum, go to a couple of questions which were asking questions about momentum only, and then when I'm done with that I move on to the next chapter. [J/1]

The discussion so far has focused on the variation in the way theory was consulted by our students when attempting to solve problems. However, the reverse interaction was also evident – students used problems as a way of checking whether or not a section of theory had been understood. The following extract illustrates the point.

> In most cases I like to read the theory and then after reading it I will try to understand it, like repeat it again, do it again and again, and understand it. Then after that I go to the example. That's what I do … to know whether I understood it or what, because if I just read the theory then I say I understand it, mass flowrate is whatever … But if I don't do examples it's like, aah, I don't know nothing. [I/1]

The above extract also hints at a more advanced interaction between the solving of problems and the learning of theory, namely, the practice of deliberately attempting problems as a way of enhancing the understanding of theory. Such practice has already been recognized as a particular type of consolidation-oriented practice and labelled *applying* theory (see section 6.1.3). The other types of consolidation practice are – highlighting, vocalizing, memorizing with understanding, and summarizing. *Applying* theory intentionally as a means of enhancing theory involves an intentional interweaving of the learning of theory and the solving of problems that is not found with the other subcategories of consolidation practice. In other words, when a student's study practice does not reach beyond the level of summarizing, the learning of theory and the solving of problems are conducted relatively independently from each other in some kind of sequential association such as that illustrated earlier; typically, theory is learned and then problems related to that theory are attempted. However, when a students' suite of study practices includes the practice of 'applying', that student may intentionally interweave the learning of theory and the solving of problems, i.e. engage with problems with a deep awareness that doing so enhances conceptual understanding and intentionally thinking about the relevant concepts while solving problems so as to enhance both conceptual understanding and problem-solving skill. The following extract illustrates this integration of theory- and problem-focused engagements.

> And add to what you've learned as well. *Oh so you can add to what you learn by doing problems. Tell me about that.* That's how I work. … What are the concepts that are related [to the problem]? … So when you learn something you start from nowhere, you do the basic. You don't know much about it. You do the problems, you do the problems you see how everything else is related. Then you may, you get a broader understanding of what you're doing. And you can, as you do problems you see more things and more things and more concepts are related, are related and then it gets bigger and bigger and you just add onto what you've got. [D/2]

What the discussion so far shows is that there is variation in the way in which theory- and problem-focused study practices are exercised together: they may be exercised in a sequentially associated manner or in an integrated manner. Further, the fact that the two types of practice can and usually are exercised together in a sequential or an integrated manner suggests that they should be considered to be components of a larger meta-practice. The nature of that meta-practice – which has been labelled mastering-oriented study practice or mastering-practice – is explored next.

8.2 MASTERING-ORIENTED STUDY PRACTICE

The label 'mastering', which has been given to the combination of theory- and problem-focused study practice, is derived from the observation that when students focused only on mastering the course – when the full focus of their attention was on developing the requisite understanding and skill and any concerns about grades or preparing for tests/examinations etc. were absent from or were far back in their minds – they employed both theory- and problem-focused study practices. What is more, they employed them together either in a sequential, relatively independent manner, or in an integrated manner. Consequently, the variation in mastering-oriented study practice includes the variation associated with theory-focused study practice, the variation associated with problem-focused study practice, and, unique to mastering-practice, the variation in the way the two are exercised together when studying. When these three aspects of variation were considered together it became apparent that the variation in practice could be described in terms of the following 6 qualitatively different categories:

A *superficial* level of mastering-practice
A *comprehension* level of mastering-practice
A *consolidation* level of mastering-practice
An *integration* level of mastering-practice
A *refinement* level of mastering-practice
A *know-how* level of mastering-practice

These categories were derived conceptually by analysing how the different aspects of the variation of mastering-practice inter-relate. The analysis of this inter-relation and the derivation of the categories are explained next.

8.2.1 The conceptual development of the categories of mastering-practice

The inter-relation between the three aspects of mastering-practice and the way they are exercised together prove to be relatively straightforward to appreciate conceptually. This is because there is a progression in the level of sophistication in both theory- and problem-focused study practices so that, in most cases, the categories of one practice map onto the categories of the other practice according to their relative level of sophistication. In addition, the less sophisticated categories of the two types of practice are inherently exercised in a sequential, relatively independent manner while the more sophisticated levels of practice include the ability to exercise them together in a more integrated manner. In more detail, the associations between the different aspects of mastering-practice were identified as follows.

First, it was recognized that the variation in mastering-practice should be described by at least 5 categories each of which was associated with one of the 5 categories of theory-focused study practice. The least sophisticated category was labelled 'a superficial level of mastering-practice' and embodied the theory-focused practice of information-oriented study practice. The other categories of mastering-practice were labelled according to the labels of the theory-focused study practices which they embodied: i.e. comprehension, consolidation, refinement, and know-how levels of mastering-practice. The term 'level' is used to distinguish mastering categories from categories of theory-focused practice.

Next, it was apparent that the category of consolidation-oriented study practice should be split into two categories distinguished by whether or not the study practice had progressed to a level which included an orientation to interlace the learning of theory and the solving of problems in a mutually enhancing, integrated manner. Accordingly, the less sophisticated of the split categories includes only the consolidation-oriented practices of highlighting, vocalizing, memorising with understanding, and summarizing but excludes an orientation to interlace the learning of theory and the solving of problems; i.e. it excludes the practice of *applying* theory (see section 6.1.3). In this category of practice, the learning of theory and the solving of problems are conducted in a sequentially associated, relatively independent manner. The more sophisticated of the split categories is not constrained in this way and includes all of these consolidation-oriented practices and, therefore, the orientation to interlace the learning of theory and the solving of problems. These split categories of mastering-practice have been labelled respectively the 'consolidation level' and the 'integration level' of mastering-practice.

The third point in the conceptual development of the categories of mastering-practice is to notice that the less sophisticated levels (the superficial, comprehension and consolidation levels) do not include the tool of 'applying' that is necessary for the interlacing of the learning of theory and the solving of problems. Accordingly, such integration is precluded in these levels of practice and the learning of theory and the solving of problems are inherently conducted in a sequentially associated, relatively independent manner. However, the more sophisticated levels of mastering-practice (the integration, refinement, and know-how levels) do include *applying* and so include the orientation to interlace the learning of theory and the solving of problems.

Figure 8.1 draws these various observations together to illustrate the variation in the way theory- and problem-focused study practices may be integrated when exercising a mastering-oriented study practice. The device of interlaced diagonals in the graphic is intended to indicate that different aspects of learning practice may be interwoven when studying. The relative increase in the size of the graphic when progressing from less to the more sophisticated categories of practice is intended to illustrate the accompanying increase in the complexity of the practice and of the knowledge and skill developed. For ease of following the argument as it unfolds, the reader is invited to fold out the copy of this figure that is found in Appendix B, page 186.

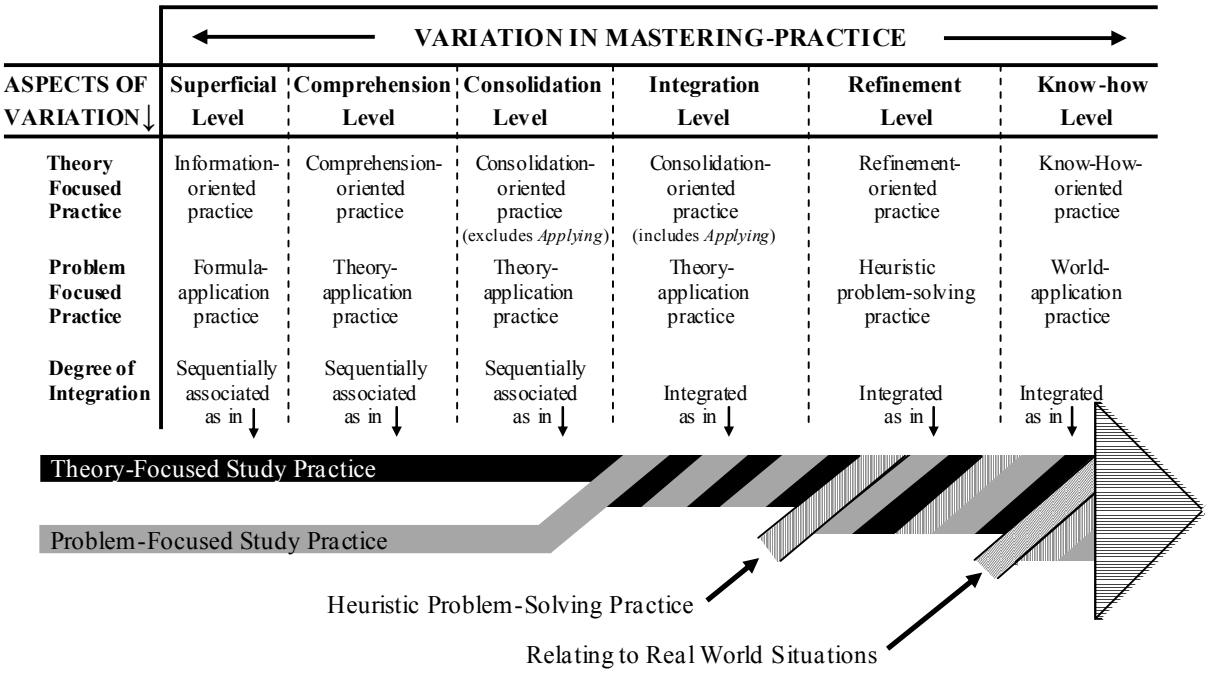


Figure 8.1: Variation in Mastering-Practice

Figure 8.1 has gone further than summarizing the observations made so far; it also indicates how the categories of problem-focused study practice map onto the categories of theory-focused study practice. The argument behind this mapping is as follows.

The first point is that the category of familiarization-oriented study practice (studying worked examples in order to become familiar with the problem solving methods used) is inherent in all problem-focused study practices and so does not need to be included as category separate from other categories of mastering-practice. The second point is that theory-application-oriented study practice presupposes the comprehension of the relevant theory and therefore is associated with any category of theory-focused study practice that develops an understanding of that theory. Clearly, it cannot be associated with a learning practice that has not progressed beyond information-oriented study practice.

With respect to how heuristic problem-solving practice is associated with theory-focused study practice, the following can be said. Heuristic problem-solving is inherently reflective and integrative in nature in that it involves reflecting on the nature of a problem situation and how its different aspects relate and can be untangled in order to arrive at and synthesize an effective way to solve that problem. As explained in the previous chapter, this is quite different from and additional to the more straightforward kind of problem-solving associated with theory-application skill. In addition, the kinds of reflective and integrative activities which are involved in heuristic problem-solving are essentially of the same kind as the restructuring and connecting activities that characterize refinement-oriented study practice; both are characterized by an orientation to analyse conceptual connections and synthesize new ones. At a conceptual level, the similarity between the two kinds of study practice is such that it would seem unlikely

that a student who practiced heuristic problem solving would not also exercise refinement-oriented study practice. It seems reasonable to argue the converse as well; a student who regularly restructures and makes fresh connections when studying theory would be expected to apply the same kind of analytical and synthetical practice when solving problems. These arguments and observations lead to the recognition of a particular category of mastering-practice that is characterized by both refinement-oriented study practice and heuristic problem-solving oriented study practice. The integrative nature of both of these practices is depicted in Figure 8.1 by means of interlaced diagonals as before. The label given to this category of mastering-practice is 'the refinement level of mastering-practice'.

With respect to how the practice of relating problems to real world situations is integrated with theory-focused study practice, it is easy to see a strong conceptual link between know-how-study practice and world-application study practice; the defining characteristic of both is the orientation to relate to real world situations. The reflective and integrative nature of both is also evidenced by that orientation. Following the argument used to define the refinement level of mastering-practice, I argue that a student who typically relates theory to real world situations will be likely to do the same with regard to problems. The converse is as likely and I argue that a student who does not typically relate theory to real world situations – i.e. a student with only a refinement-oriented study practice – is unlikely to relate problems to real world situations. Accordingly, a know-how level of mastering-practice is recognized as consisting of know-how oriented study practice and world-application study practice integrated together. Again, interlaced diagonals are used in the figure to illustrate the integrated nature of this category of practice.

8.3 THE VARIATION IN MASTERING-PRACTICE: THE OUTCOME SPACE

The previous section identified 6 categories of mastering-oriented study practice. These are summarized in in Table 8.1 and are described in more detail thereafter.

Table 8.1: The Variation in Mastering-Practice: The Outcome Space

Aspects of Variation → Dimensions of Variation ↓	**Theory-Focused Study Practice**	**Problem-Focused Study Practice**	**Association between Theory- and Problem-Focused Study Practices**
Superficial Level	Information-oriented	Formula-application oriented	Sequentially associated
Comprehension Level	Comprehension-oriented	Theory-application oriented	Sequentially associated
Consolidation Level	Consolidation-oriented (excluding 'applying')	Theory-application oriented	Sequentially associated
Integration Level	Consolidation-oriented (including 'applying')	Theory-application oriented	Integrated
Refinement Level	Refinement-oriented	Heuristic problem-solving oriented	Integrated
Know-How Level	Know-how oriented	World-application oriented	Integrated

Superficial level of mastering-practice

This is a minimalist category characterized by a theory-focused study practice no more advanced than information-oriented and a problem-focused study practice no more advanced than formula-application (plug and chug) oriented practice. The superficiality of the two types of practice precludes any meaningful integration of the two practices when studying.

Comprehension-level of mastering-practice

The theory- and problem-focused practices in this category are no more advanced than that of comprehension-oriented and theory-application practice respectively. A student manifesting this practice does not routinely attempt to consolidate their comprehension of theory by using consolidation tools such as summarizing and depends only on reading texts to develop an understanding of the course material. The student approaches problems either as formula- or theory-application problems. The solving of problems and the learning of theory tend to be conducted as sequentially associated, relatively independent activities.

Consolidation-level of mastering-practice

This category is an advance on the previous one in that it includes, in addition to the reading of textual material, some consolidation tools – highlighting, vocalizing, memorizing, or summarizing – to deepen the grasp of theory as presented in the course material. As in the previous category, problems are conceived as theory application problems and the solving of problems and the learning of theory tend to be conducted sequentially as relatively independent activities.

Integration-level of mastering-practice

In this category of mastering-practice, the solving of problems may be integrated with the learning of theory as it includes the consolidation tool of 'applying' theory. The characteristic of this tool is the intention of enhancing the understanding of theory by interlacing the activities of learning theory and solving problems. In other respects, this category of mastering-practice includes the same suite of practices as the previous category.

Refinement-level of mastering-practice

This category of mastering-practice is more advanced than the previous category with respect to both theory- and problem-focused practices. It includes refinement-oriented study practice which uses refinement tools that seek to deepen the understanding of theory by 'restructuring' it and making new connections ('connecting') and, by so doing, developing and refining 'knowledge objects'. With regard to problem-focused practices, it includes the problem-solving practice that uses and develops heuristic problem-solving skills for the solving of complex problems. The two practices – refinement-oriented and problem-solving study practices – may be mutually integrated when studying because both are inherently reflective and integrative in nature. Put differently, a student with a reflective disposition is likely to think about the theory they are learning and the problems they are solving in ways that are characteristic of refinement-oriented and heuristic problem-solving study practices.

Know-how-level of mastering-practice

This category of mastering-practice is similar in nature to the previous one except that the focus of refinement attention is frequently turned outwards to the world as well as inwards to the specifics of the theory being learned and the problems being tackled.

8.4 THE STRUCTURE OF THE OUTCOME SPACE

In this section the structure of the outcome space of the variation in mastering-practice and the aspects and elements that characterize each dimension of variation are discussed in more detail. Figure 8.2 compiles the relevant information extracted from the three outcome spaces originally presented as Table 6.2, Table 7.1, and Table 8.1. (The reader may like to fold out the copy of the figure in Appendix B, page 187.)

As Figure 8.2 indicates, the variation in mastering-practice is characterized in terms of six categories which form a progression from a 'superficial level' to the 'know-how level' of mastering-practice. The progression is inclusive in that any level presumes and includes the less sophisticated levels of practice. Three aspects characterize the variation: theory- and problem-focused study practices and the way in which these are integrated together. Each aspect of variation involves a number of elements which take different 'values' in each of the six categories of variation. These are indicated in the figure.

The aspect of 'theory-focused practice' is characterized by three types of elements: the 'knowledge-type' which a student implicitly discerns as being the object towards which the practice is oriented; the type of resource or learning tool which is utilized; and the specific strategy employed in the practice. Each category of mastering-practice is associated with a different knowledge-type, resource/learning tool, and strategy as indicated in the figure. The consolidation and integration levels of mastering-practice both share the same knowledge type, i.e. 'consolidated theory'. Constraint thresholds are associated with the transition from one type of strategy to another as indicated by the circled numbers 1 to 7. The 'transition' from *restructuring* to *connecting* is an exception because these strategies are qualitatively not sufficiently different to constitute a constraint threshold. Of the 7 constraint thresholds, 5 coincide with the boundaries between adjacent categories of mastering-practice.

The aspect of 'problem-focused practice' is characterized by four types of elements: perception of the type of problem-solving skill to be developed; the type of strategy employed to develop that skill; perception of the type of problem being tackled; and perception of the type of problem-solving task being engaged. Each category of mastering-practice is associated with different 'values' of these elements as indicated in the figure. The exceptions are comprehension, consolidation and integration levels of practice which all share the same elements because they are all associated with the same category of problem-focused study practice, namely, a theory-application study practice. Constraint thresholds are associated with the transitions from one category of problem-focused practice to the next, specifically, from formula-application to theory-application practices and from theory-application practice to heuristic problem solving. These are indicated in the figure by the circled numbers 8 and 9 which coincide with the thresholds marked as 1 and 6 respectively.

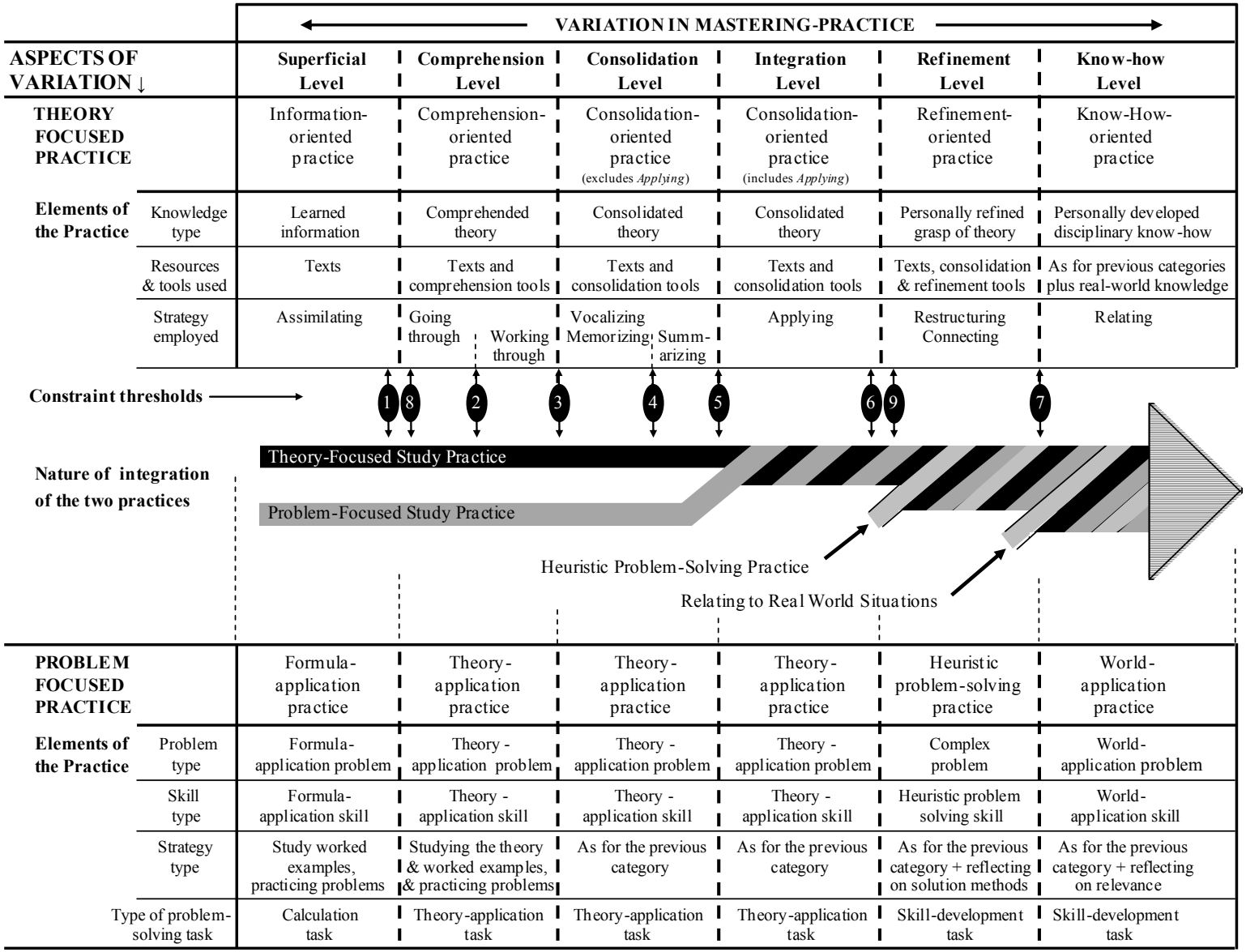


Figure 8.2: Graphical Representation of the Variation in Mastering-Oriented Study Practice

8.5 THE STRUCTURE OF UNDERSTANDING AND SKILL, AND THE QUALITY OF STUDENT LEARNING

As can be seen from Figure 8.2, each category of mastering-practice is associated with a particular knowledge-type and a particular type of problem-solving skill. The implication of this is significant because it suggests a link between the type of mastering-practice and the type of understanding and skill which that mastering-practice aims to develop. More generally, it indicates a tangible link between the quality of learning practice and the resultant quality of student learning. Here quality of learning is taken to mean *the depth of knowledge, understanding and skill that is developed when a student learns*. In this section, that linkage is formalized and operationalized. The first step in that direction is to formalize the link between the structure of mastering-practice and the structure of understanding and skill. The second step is to formalize the link between the structure of understanding and the quality of student learning.

8.5.1 A practice perspective on the structure of understanding and skill

The variation in mastering-practice is associated with a wide variation in the type of knowledge and understanding which is explicitly afforded by the exercise of that practice. This range stretches from 'information' at one end to 'practical know-how' at the other. Similarly, the variation in mastering-practice is associated with a wide range of problem-solving skills from formula-application skill at one end to world-application-skill at the other. In addition, the degree of inter-relatedness of understanding and skill which is afforded by the exercise of different levels of mastering-practice varies from relatively unconnected to deeply integrated and related to real world situations. These ranges of categories of understanding/knowledge, problem-solving skill, and degree of integration constitute a perspective on the nature and structure of understanding and skill that provides a convenient structure and reference framework for thinking about different levels of understanding and skill. Table 8.2 compiles the relevant information into a coherent and formalized structure.

Each row in the table represents a particular category of mastering-practice and includes the associated kinds of understanding, knowledge and skill, and indicates the degree to which these are integrated. Moving down the table from category to category constitutes a progression in the degree of sophistication of understanding and skill and a progression in the degree to which understanding and skills are integrated. The progression in the sophistication of understanding involves an increase in the degree to which knowledge is consolidated, refined, restructured, interconnected conceptually, and related to real world situations. The progression in the sophistication of skills involves an increase in the range and complexity of theory application ability, and in the ability to unravel and solve complex and world related problems. These progressions imply, and in effect describe, an increasingly more complex structure of understanding and skill. As such, the table provides a perspective on the structure of understanding/skill generally associated with technical subjects, and also describes the kind of understanding/skill that might be attained by students when they exercise their mastering-practice.

Table 8.2: A Practice Perspective on the Structure of Understanding and Skill and its Link to Mastering-Practice

	THE STRUCTURE OF UNDERSTANDING AND SKILL		
Level of mastering-practice	**Type of Knowledge**	**Type of Problem-Solving Skills**	**Degree of Integration**
Superficial	Information	Formula-application skill	Learning of theory and solving of problems are conducted relatively independently.
Comprehension	The above plus comprehended theory	The above plus theory-application skill	
Consolidation	The above plus consolidated theory	As above	
Integration	As above	As above	Learning of theory and solving of problems are interlaced and integrated.
Refinement	The above plus personally refined theory	The above plus heuristic problem-solving skill	Learning of theory, solving of problems, and heuristic problem-solving are interlaced and integrated.
Know-How	The above related to real world situations	The above plus world-application skill	Learning of theory, solving of problems, heuristic problem-solving, and relating these to real world situations are interlaced and integrated.

8.6 THE LINK BETWEEN MASTERING-PRACTICE AND THE QUALITY OF LEARNING

To be able to identify, in a reasonably rigorous manner, a link between students' learning practices and the quality of their learning is critically important. Without such a link there can be no rigorous basis for designing measures intended to improve student learning by facilitating an improvement in their learning practices. This study provides a linkage that involves three connections – the connection between levels of mastering-practice and conceptions of knowledge; the connection between conceptions of knowledge and the structure of knowledge and know-how; and the connection between the structure of knowledge/know-how and the quality of student learning. The first two connections were discussed in the previous section and have been illustrated in Table 8.2. The connection between quality of learning and the structure of knowledge and know-how is addressed next. Thereafter, the link between quality of learning and quality of learning practice is taken further by describing specific ways in which the practice of mastering-practice affords and constrains the development of different levels of understanding and skill. The section concludes with an empirical demonstration of the link between mastering-practice and the quality of student learning.

8.6.1 An alternative definition of the 'Quality of Learning'

Table 8.2 depicts a wide range of complexity and sophistication of understanding and skill. It extends from an exceedingly superficial level to the very sophisticated levels associated with expertise. As

such, the structure embodies a comprehensive range of the levels of understanding and skill that might be developed when an engineering student goes about studying and learning.

Earlier, 'quality of learning' was defined as the depth of knowledge, understanding and skill that is developed when a student learns. The structure of knowledge and know-how just described enables an alternative definition that is more specific and fine-grained in nature. On this basis, the 'quality of learning' is taken to be *the level of understanding and skill reached as a result of studying and learning activities on a scale defined by the structure of understanding and skill indicated in Table* 8.2.

While this definition may have general utility, its specific utility here is that it describes quality of learning in terms that relate directly to the kinds of understanding and skill afforded by the exercise of specific types of mastering-practice.

8.7 AN EMPIRICAL TEST OF THE INFLUENCE OF MASTERING-PRACTICE ON QUALITY OF LEARNING

In section 6.3.3, an empirical investigation was undertaken into the relationship between the theory-focused study practice of students on entry and their academic performance in the first semester of 2008. The results (Table 6.3) showed a positive correspondence between the sophistication of the study practice and the quality of academic performance. A similar investigation is undertaken here with regard to a student's overall academic performance for all subjects at year end and the sophistication of their mastering-practice at year end.

The final overall aggregate mark for all first year subjects was taken as an indication of the students' academic performance. (The limitations inherent in such an indication were discussed in section 6.3.3.) That performance was classified into three categories: a failing aggregate (<50%); a passing aggregate (>50%); and an excellent or distinction-level aggregate (>70%). The assessment of the level of sophistication of a student's practice of mastering-practice was based on which category of theory-focused study practice they were exercising at the end of their first year of study as interpreted from data gathered from their interviews towards the end of the academic year. Theory-focused study practice categories were used instead of mastering-practice categories because they constitute the core of the mastering-practice categories and because it was difficult to assess accurately which category of problem-focused study practice some of the students were exercising. The results from only 26 of the 31 students are included. As indicated elsewhere, the data from one student was discarded, two students withdrew or left the study at mid-year, and the study practice of two students was confused because, for them, study was not a dominant priority.

The results of this investigation are shown in Table 8.3 and Figure 8.3. They show a very clear and positive correspondence between the sophistication of study practice and the level of academic performance achieved. As with the previous investigation there was a very marked improvement in

performance when moving from a consolidation-level to a refinement level of practice. With regard to students functioning at a consolidation level of practice (SP3), 64% passed but none did so with distinction. However, all students functioning at a refinement level of practice (SP4) passed and 25% did so at a distinction level. The numbers of students who functioned at a comprehension level (SP2) or to some degree at a know-how level (SP4/5) were relatively small – 4 and 3 respectively – and so comparisons involving these students must be treated with caution. However, half of the former failed and all of the latter passed at or near a distinction level.

Table 8.3: Level of Academic Performance vs Sophistication of Study Practice

		% of the students (Number of students) in the SP category performing at the indicated level		
Study Practice (SP) Category	**Number of students**	**Fail (<50%)**	**Pass (>50%)**	**Distinction Level (>70%)**
Comprehension-oriented (SP2)	4	50% (2)	50% (2)	0
Consolidation-oriented (SP3)	11	36% (4)	64% (7)	0
Refinement-oriented (SP4)	8	0	100% (8)	25% (2)
Refinement- & Know-how oriented* (SP4/5)	3	0	100% (3)	100% (3)

* These students did not appear to function fully at a know-how level but did appear to have a know-how oriented disposition.

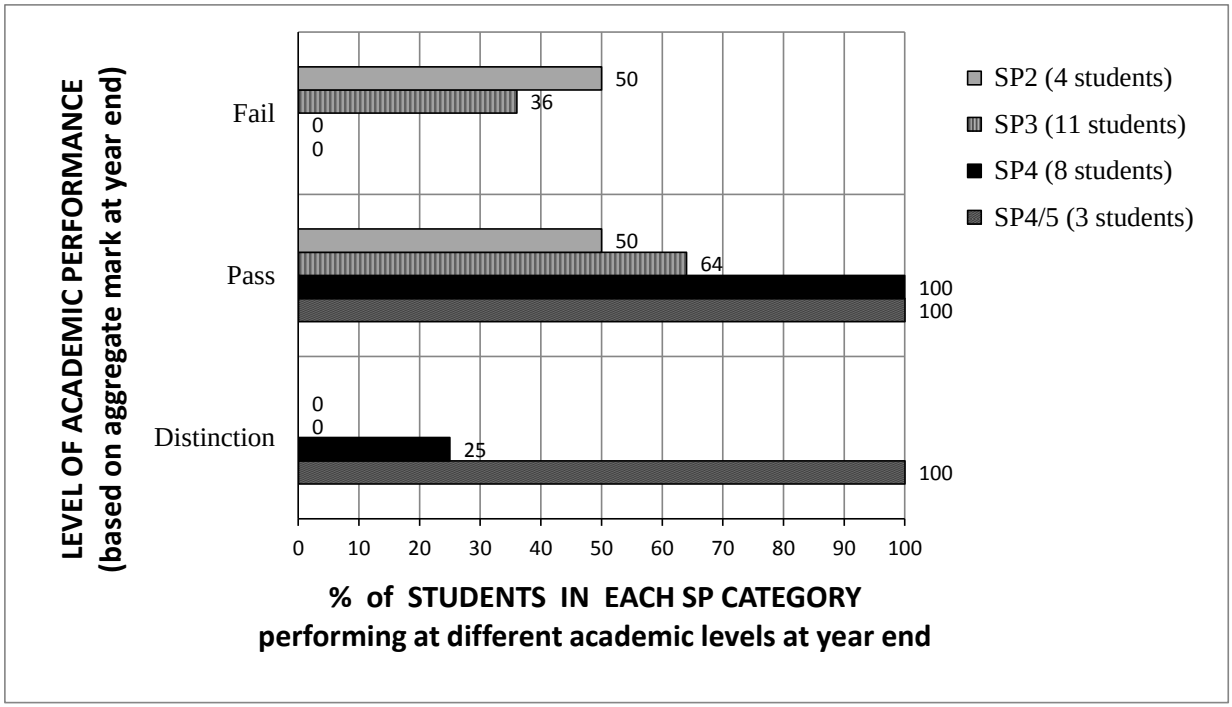


Figure 8.3: Academic Performance vs Study Practice

These results lend some empirical support to the correspondence between the quality of learning and the sophistication of study practice, but the degree of support is limited by the small numbers in the sample and by the real possibility that other factors influenced the level of academic performance achieved. For example, the two students who functioned only at a comprehension level yet passed well may have done so because of other factors. One of them had formed a strong study group with a student who functioned at a refinement level of practice. The other was exceptionally bright. He was the only student among five successive cohorts of entrants from 2004 to 2008 (approximately 750 students) who, when assessed by means of the Advanced Ravens Matrices instrument, achieved full marks.

CHAPTER CONCLUSION

This chapter has developed an understanding of the nature of mastering-oriented study practice from a synthesis of the natures and interaction of theory- and problem-focused study practices. This is the type of learning practice that is exercised when there is nothing else on a student's mind except mastering the understanding and skill which they perceive the course is intending for them to master. Consequently, the quality of the learning that results from the exercise of this practice is very directly influenced by the quality of the learning practice. The chapter explored this influence and provided a tangible method for evaluating its nature. The next chapter investigates other aspects of learning practice and the influence which they have on the quality of learning of our students.

CHAPTER 9: DATA ANALYSIS AND RESULTS 4: THE VARIATION IN OTHER ASPECTS OF LEARNING PRACTICE

The three previous results chapters presented the study findings with regard to theory- and problem-focused study practice, and mastering-practice. In this results chapter, other aspects of learning practice are addressed, more specifically test-focused study practice and learning management practice. Another two types of learning practice were also analysed in the study – help-seeking and study-group practice – but the results of these analyses are not reported here. In both cases, the interview data was too superficial for in-depth analysis and the findings proved not to be particularly insightful or interesting. Further research in these areas is indicated.

With regard to test-focused study practice and leaning management practice, the relevant interview fragments were analysed in the same way as before and the same general format for presenting the findings is employed. Findings with regard to test-focused study practice are reported in Part A of the chapter, and those related to learning management practice are reported in Part B.

PART A: THE VARIATION IN TEST-FOCUSED STUDY PRACTICE

The study practices analysed up to this point relate to a learning context where course assessments are very much in the background of students' minds because the focus of attention is on trying to master the requisite knowledge and skills. This contrasts with the learning context of the practices analysed in this part of the chapter where students are 'learning for tests' as opposed to 'learning for mastery'; they are either preparing for an imminent test or examination, or their learning activities are strongly influenced by the perceived need to prepare for tests they must face in the not too distant future. In one sense, most study activities at university lead ultimately towards some kind of assessment and are about preparing for such assessments. As one student put it, "You know, it's great that you understand but at the end of the day, it kind of is about marks – you wouldn't like to fail" [AB/2].

Learning-for-mastery and learning-for-tests are obviously related because both focus on the same material and involve learning, and tests/exams are intended to assess the extent to which students have gained the kind of mastery which a course intends to develop. However, many students reported that when a test/exam was pending they employed practices that were different from those which they used when assessments were not explicitly on their minds. There were also students who stated the opposite; their study practice did not change when preparing for tests/exams except for putting in extra

study time. It is therefore evident that the variation in mastering-oriented study practice among the students is likely to be quite different to the variation in their test-focused study practice.

9.1 PRACTICES PECULIAR TO 'LEARNING-FOR-TESTS'

A phenomenographic analysis of interview fragments related to test-focused study practices yielded four categories of test-focused study practice. The first three are peculiar to learning for tests and are listed below and discussed thereafter.

Reproduction-oriented study practice
Pattern recognition study practice
Strategic study practice

The fourth category is 'learning normally', that is, focusing on mastering the requisite understanding and skill. This is identical to the mastering-practice described in the previous chapter and so is not discussed here; it is merely included in the outcome space that is presented shortly.

9.1.1 Reproduction-oriented study practice: Rote Learning and Cramming

This category of test-focused study practice, labelled reproduction-oriented study practice, is characterized by a focus on learning information for reproduction in tests/exams by repeated reading of the information for memorization with little or no regard for understanding the material being 'learned'. These features of the practice are exemplified in the following interview extract.

> I would read something through and through and then know to say it without looking on that page. Just, I don't understand that thing but I can say it. [T/1]

Two subcategories of this practice were evident from the analysis: rote learning and cramming.

Rote Learning: The following extract describes the nature of rote learning very clearly – 'learning' or memorizing the information found in the course material and/or communicated by a teacher in order to reproduce it in a test/exam.

> Try to learn so that when the test comes I produce exactly what I was told. That's what I was trying to do. *Really? That's what you were trying to do – just reproduce?* Reproduce what I was told. *And that is what you were used to doing in school.* Exactly sir. *So you had in mind that I've got to take this information and give it straight back to them?* Sir, that's ... right ... They're telling us facts … I am just going to try to give them back because they are correct, they are right. … I believe he's a qualified teacher – [he] won't lie to me. [AF/2]

It is interesting to note the extent to which this student's practice was influenced by her conception of knowledge and of learning: i.e. knowledge consists of facts communicated by authority figures; and learning involves memorizing that information in order to reproduce it in tests.

Cramming: This practice was introduced previously in see section 6.1.1 as a type of information-oriented study engagement. As explained there, it involves learning facts, formulae or information for recall in a pending test/exam by using some kind of memorization technique or intense last-minute exposure to the information to be learned. The intention behind the engagement is typically short term;

"when you cram stuff in your head … You don't remember what you've done for the previous test because you've just crammed it, short term – in and out you know" [A/1]. The reason for cramming varies over a range as indicated and illustrated below.

Cramming as an intentional test-preparation strategy

> Like, I could work a lot harder, and I could spend longer periods of time. Like spend the two weeks that I've known about the test and do it in little sections. Then leave it for the last 5 days and just cram it in. [B/2]

Cramming because of time pressure or a time management failure

> It was too late for me to ask questions and other people did understand and they tried to explain to me but I just didn't understand what they were saying. So, I resorted to cramming. [AB/2]

Cramming as a fall back strategy when unable to understand

> For physics I used to cram my notes because some words in physics you just can't get. So, read through the notes, get them [as] best [you can], if you don't ['get them'], then you can cram them. [K/1]

Cramming as an act of desperation:

> I had to [cram] 'cos I was failing. So I was desperate for anything that could help. … when I first looked at it … and I eish, it's kind of hard. And [I] don't think I will be able to do this. Might as well stick to my old ways … what if this … didn't work and I still don't perform … I don't have time to waste … so I might as well stick to my old ways. [M/2]

In some ways, cramming is 'last minute' rote learning – learning information at the last minute in preparation for a test/exam. However, it is qualitatively different from rote learning, because the conception of knowledge behind the practice is different. Rote learning views course material as information simply because that is the conception of knowledge behind rote learning. Cramming also involves learning information but not necessarily because that is how knowledge is conceived. It may be conceived that way, but the reasons for cramming are various, as indicated in the above extracts; they boil down to a perception of a need to learn as much as possible in a short period of time. The 'crammer' may actually have a very sophisticated conception of knowledge as was the case with the student, quoted below, who crammed out of desperation even though his normal study practice was at a much more sophisticated level (refinement- and know-how oriented study engagements in this case).

> But for matric it was just desperation, it was just learning this and learning it for the sake of learning it, not for understanding it. So that's how I learned – memorising, memorising. [U/1]

9.1.2 Pattern-recognition study practice

Pattern-recognition oriented engagements are based on the conception that past test/exam papers and the questions in them follow a pattern, and that to be aware of the nature of such patterns can guide one's preparation for tests/exams in ways that can improve the grades obtained. This is illustrated in the following extract.

> You know that … these [exam questions] are more or less the same so the more practice you get [at answering those questions], ja, the more chance, maybe there is a high chance of you getting the same [question] … obviously not with the same values but the same format of the question. [AB/2]

While the awareness of patterns in past paper was widespread among the students, they acted on this awareness in different ways which have been categorized below as 'reviewing past papers', 'studying with past papers' and 'studying past papers'.

Reviewing past papers: Here the intention behind engaging with past papers is simply to become familiar with the type of questions which might come up in the test/exam.

> *You mentioned also that you went through past papers. Was that an important part of your studying?* I think it was important part in that it exposed you to a wider variety of questions not so much of just drilling it into your head, being exposed as much as you can so that you can deal with whatever comes should something difficult arise. Especially in terms of practical subjects I definitely find past papers …and past questions and things like that to be helpful. [C/1]

Studying with past papers: The strategy here is to include questions from past papers as a resource while studying; questions from past papers are used alongside other sources of examples or problems.

> I was working on the problems and they give us question papers that were set by the department of education. …We were given the memorandum, and if you don't know that sum [you would refer to the memorandum]. *So you actually had the exam paper and the solution.* Yes. *To all of them? And you referred to them?* Yes. *How did you use those?* I was studying to do the question papers and then to see how much I know that thing. If I fail that thing I go back to the book and practise it again, and then do it again. *When did you refer to the memorandum then?* I'll refer to the memorandum … I'll set my time 2 hours and then answer that question paper and then see how much I scored on that paper. *And mark yourself.* Yes. [T/1]

Studying past papers: This category takes the previous one further in that past papers are actually studied in order to 'learning how to answer test/exam questions' as the extract below puts it. Questions from past papers, often with model solutions, are studied as exemplars with the intention of identifying recurring 'standard' assessment patterns so that standard answers can be developed and rote learned.

> *How did you get through your science then?* As I'm saying here, the questions in matric they were the same. Take all those question papers you get to understand how they are being asked, what is being expected, how you have to answer them. ... I used to understand how to solve those problems. [G/1]

9.1.3 Strategic study

This category of test-related study practices is an example of what Entwistle calls a 'strategic approach to studying' (Entwistle & Ramsden, 1983). The practice involves using a strategic mix of study strategies that are guided by the student's conceptions of what will earn the most marks in tests/exams. The following extract illustrates the practice.

> In the beginning of the year I thought it was like back at high school. If you cram that definition… and you cram the equations then you're good. So you didn't have to understand all of this cuz you know that in the test it's all about definitions and the equations and substituting everything. Right now… if you cram a definition it's not going to come up anyway, you're wasting your time. If you cram an equation, you have to derive it in the test before you use it, so if you crammed it… then you lost 6 marks and 10 marks, bad news. You've got 40%. So it's better to go through your notes so that you can understand how they derived it, cuz in the test it counts more to derive it, meaning the understanding is worth more than just a substitution. So you need to understand in order to get that good mark. [K/2]

As the above extract shows, the exercise of strategic study is based on an awareness of the general assessment strategy which is learned either from the teacher or from having done many past papers or both. The practice involves paying particular attention to the identification of (1) those topics that are not likely to come up in the test/exam and so can be given little or no study attention; (2) those topics which are generally assessed by calling only for information – 'facts' or 'formulas' as in the above extract – and so are best studied by cramming and memorization; and (3) those topics which will require 'understanding' and so need to be 'studied normally or properly'. The practice may also include

(4) 'spotting' (reported by students J and T) – i.e. identifying topics that have a particularly high probability of coming up in the test/exam and giving these greater attention when studying.

9.2 TEST-FOCUSED STUDY PRACTICE: THE OUTCOME SPACE AND ITS PEDAGOGICAL IMPLICATIONS

Table 9.1 summarizes the categories of test-focused study practice that were described in the previous section. The structure of the associated outcome space is discussed after the table. Particular attention is given to constraints and affordances that are inherent in the various aspects of test-focused study practice.

Table 9.1: The Variation in Test-Focused Study Practice: The Outcome Space

Category		Description and Focus of Attention	Underlying conceptions about how to earn marks in a test/exam
1	**Reproduction-oriented study practice**	The practice of learning and memorizing information by means of rote learning or cramming for the purpose of reproducing the information in tests or examinations. ***Focus of attention: Information***	Marks are earned by reproducing the required information.
2	**Pattern recognition study practice**	The practice of engaging with past test/exam questions to identify patterns that typically come up for the purpose of familiarization (reviewing past papers), or developing relevant skills (studying with past papers), or developing test-answering skill (studying past papers). ***Focus of Attention: Past papers***	Marks are earned by being familiar with the types of questions that come up and how to answer them.
3	**Strategic study practice**	The practice of understanding the assessment patterns used in tests/exams in order to identify topics that are likely to come up and to study these in the way perceived necessary for earning most marks. ***Focus of attention: Assessment strategies***	Marks are earned by being aware of assessment patterns and studying accordingly.
4	**Mastering-oriented study practice ('Learning normally')**	The practice of focusing on the mastering of the understanding and skills perceived to be the objectives of the course without paying undue attention to assessment patterns or issues. The variation in this practice is summarized in Table 8.1 and Figure 8.2. ***Focus of Attention: Requisite understanding and skills***	Marks are earned by having mastered the relevant knowledge, understanding and skill.

The table identifies four qualitatively different categories of learning practice that may be exercised in the context of having to prepare for impending assessments. Several structural features of the outcome space are interesting. The first is that the progression from categories 1 to 4 corresponds to an increase in the sophistication of the conceptions underlying the learning practice with respect to what it takes to earn marks and perform well in assessments: i.e. marks can be earned by reproducing information; by being familiar with past questions and how to answer them; by being familiar with the assessment strategies and studying accordingly; and by mastering the requisite knowledge, understanding and skill.

A second structural feature is that there is an accompanying progression in the sophistication of the test-preparation methods: i.e. from straightforward memorization; to being alert to and learning the patterns

in past papers; to being alert to and learning assessment strategies and studying accordingly; to doing the hard work of actually studying and learning in ways intended to develop the requisite understanding and skill. This progression, however, applies only to the degree of sophistication and is not developmental as such because the focus of attention and the type of strategies employed in each category are unrelated to each other. To earn marks by reproducing information requires a focus on information and how to assimilate and memorize it. To earn marks by being familiar with how questions are asked and how to answer them requires a focus on past papers and attentiveness to patterns that may be evident in those papers. To earn marks by aligning study methods to the pattern of assessment requires a focus on the assessment strategy and being selective about what is studied and how it is studied. To earn marks by having mastered the requisite knowledge and skill requires a serious focus on mastering the relevant knowledge and skills. These strategies are not mutually exclusive and, consequently, a student can use any of them to a greater or lesser degree in whatever way seems appropriate to them.

A third structural feature that is evident in the outcome space is the distinct shift from category 3 to 4 in Table 9.1 with regard to the objective of studying. Up to category 3, the objective of studying is to prepare for the test/exam and, to one degree or another, to 'learn-how-to-pass-the-test', to play the 'assessment game' or to 'beat the system' (Student O) by orienting one's study according to criteria other than that of developing the requisite knowledge/skill. The objective of learning in category 4 is to develop that requisite knowledge/skill. One implication of this observation is that the three types of learning practice that are peculiar to test-focused study practice offer alternatives to mastering-practice that firstly are less effective in developing the requisite understanding/skill, and, secondly, divert attention from learning-for-mastery towards learning-how-to-pass-the-test.

A fourth structural feature of the outcome space has to do with the resources used by the test-focused study practice and the students' conceptions of these resources and how to use them. The resource used by reproduction-oriented practices is the course material itself which is viewed as the source of the information which must be rote-learned or crammed so that that information can be reproduced to earn marks in tests/exams. This conception constitutes a constraint to learning because of its focus on learning information rather than developing understanding. For students with this conception to overcome this constraint, they need to become aware that few if any marks will be earned in tests merely by the reproduction of information.

The type of resource used by pattern-recognition study practices is past papers or questions from past papers. There is variation in how students view these and use them. With the sub-practices of *reviewing past papers* or *studying with past papers*, the resource is conceived respectively as a means of becoming familiar with the type of questions to expect or as an additional source of problems to work on. With the sub-category of *studying past papers*, the resource of past papers is viewed as embodying

exemplars, and that standard answers to those exemplars can be rote-learned. This conception constitutes a constraint on learning because it bypasses the intent of tests/exams which is to assess the level of understanding or skill that has been developed. For students with this conception to overcome the constraint they must be convinced that the practice is futile because the tests/exams are not built on sets of standard questions with standard answers.

The type of resource used by the practice of strategic study is knowledge about the assessment strategies behind tests/exams – i.e. details about the structure and focus of the questions asked and the kind of marking schedules used. The practice is based on the conception that it is possible to gain such insight and that performance in tests can be enhanced by studying according to such knowledge. This conception is a constraint on learning because it bypasses the intent of tests/exams to assess the general level of students' mastery of the course material and relevant skills. To overcome the constraint requires that the efficacy of the practice is subverted by varying the assessment strategy, and that students become aware of this so that they realize the futility of attempting to discern the kind of details just described.

PART B: THE VARIATION IN LEARNING MANAGEMENT PRACTICE

This part of the chapter focuses on the variation in learning management practices that was evident among the students – i.e. the different ways in which the students related to the phenomenon of managing their overall study effort. Table 9.2 lists the aspects of this practice that were mentioned in the student interviews. The table also gives brief descriptions of the various activities and dispositions associated with this practice.

Although the list of factors in the table is extensive, it was found that the influence of these factors on the students' learning practices could be described in terms of just two aspects – study prioritization and scheduling. 'Study prioritization' encapsulates the dispositional influences on learning management while 'scheduling orientation' embodies the skills and dispositions of a student with regard to scheduling in general. Accordingly, three inter-related analyses were undertaken: an analysis of the dispositional side of learning management as embodied in the phenomenon of 'study prioritization'; an analysis of the students' scheduling orientation as it related to learning management; and an analysis of their learning management practices as a whole. In each case, the methodology used was as before. The findings of these analyses follow.

Table 9.2: Dispositions and Activities Associated with Learning Management Practices

	Dispositional attributes			Learning Management Activities
1	**Study prioritization** Degree to which study was a priority for the student.		A	**Time management** Scheduling and managing the allocation of time for study and for other life priorities.
2	**Confidence** Level of the student's self-confidence and confidence in their academic ability.			
3	**Motivation** How motivated the student was to study and learn.		B	**Study management** Developing and managing the daily and weekly schedule of time allocated for study as well as the schedule of which subjects to study and when.
4	**Disposition** General temperament of the student.			
5	**Discipline** How disciplined the student was in persevering in tasks and plans they had set for themselves.		C	**Test preparation management** Scheduling and managing when time is allocated for preparing for tests and examinations.
6	**Hard working** The amount of time and effort given to study.			
7	**Organized** How organized the student was in planning and executing their work.		D	**Work load management** How time, study and test-preparation management are coordinated in the effort to cope with the overall work load.
8	**Attributions** Student's locus of control. Extent to which quality of performance was attributed to one's ability, to the level of one's application, to others or to circumstances.			
9	**Interested** The level of interest in science, maths and engineering, and knowing about the world.			**Regulation of learning** The monitoring and control of the quality of learning when the student is actually engaged in learning and studying activities. This category of learning management activities was not analysed with the above activities because it is too closely associated with the specifics of the different types of learning and study engagements that are addressed in chapters 6 and 7. It is listed here for completeness.
10	**Reasons** Reasons for choosing to study chemical/metallurgical engineering.			
11	**Expectations** Expectations of what university would be like.			

9.3 THE DISPOSITIONAL SIDE OF LEARNING MANAGEMENT PRACTICE: STUDY PRIORITIZATION

The analysis of the dispositional attributes listed in Table 9.2 focused on identifying the qualitatively different ways in which students related dispositionally to managing their learning. When the available data was analysed it became apparent that 'study prioritization' – the degree to which study and learning was a priority for a student (attribute 1 in Table 9.2) – was foundational. In many respects, the influence which the other dispositional attributes exerted on learning management boiled down to how they influenced study prioritization. Accordingly, the conclusion was reached that, with regard to learning management, study prioritization was the only dispositional attribute that needed to be considered. The subsequent analysis identified the following four categories of variation:

Study is the chief priority
Study is not a demanding priority
Study is not a dominant priority
Study is a declining priority.

Each of these categories is described and illustrated below.

9.3.1 Study is the chief priority

This category of study prioritization requires little elaboration or illustration; a student, in prioritizing the types of activities to which they give their attention and effort, relates to study/learning as their chief priority. Other priorities, such as staying healthy, socializing, playing sport etc., are not ignored but are engaged appropriately in the context of giving first priority to study and learning.

Other dispositional features that characterize this category are high levels of motivation, an ambitious temperament, real interest in understanding the world, and strong aspirations to do well academically and to become an engineer.

9.3.2 Study is a non-demanding priority

In this category, the student's experience of study is that it is 'easy' in that satisfactory, often top-of-the-class, academic performance can be achieved without having to expend a great amount of effort. Put another way, the demands of studying are entirely manageable without having to sacrifice other interests or indulgences (such as sport, socializing or TV watching). Accordingly, study is experienced as something that can be 'fitted in' among other interests and so does not have to be given general priority over other interests. There will of course be times when intense engagement in study is necessary but not in a way that is qualitatively much different from the way other priorities demand occasional intense attention.

Three dispositional features characterize this category of study prioritization: considerable self-confidence (derived from the experience of learning quickly and easily at school); an average to low level of interest in learning and knowing about the world; and a temperament that is somewhat casual, bordering on laziness, and possibly even somewhat rebellious. The attributes of discipline, being organized and hardworking are under-developed traits in this category because they have not been much exercised in the past. To illustrate these features, a commented composite of extracts from the transcripts of student R is given below.

> I did enjoy my high school because I was one of the best there. … *It strikes me that you're quite confident with your ability?* Yes, I'm confident. …*What would you say is the reason you did well at matric?* Oh…I think it's because I'm a bit smart. And I can say that…last year I used to study but then I was not really, like, into studying, I was a bit playful and all that. *[Laughs]* So I think it was [because I was] a bit smart. … *How did you organise your time?* Yes, that's also my problem. I can't really organise my time. That's my biggest problem. I can't organize. *Was that at school?* Yes, even at school because normally at school I didn't even do my homework, because I will watch TV the whole day. … *It was like it was too easy for you?* Yes, it was easy. High school is easy. …The thing is, last year, it was easy because … my teachers can speak my language so it was more of something easy to understand when they were teaching in class. *It sounds to me that at school you could study and you're on top straight away.* Yes.… *You gave me the impression that ... you could [quickly get] what was going on in the class.* Yes. *Just like that.* Well if I didn't understand I was going to ask the teacher at that time… *Straight away?* Yes. I make it a point that I don't go out a class without understanding. ... *How much studying did you do in that period?* When I was not serious? *Yes.* ... Maybe like study at [timetabled] study-time at school and that's it for the day. We had maybe two hours at school for studies. *You had study periods at school? And you did everything in there?* Yes. Yes. … [*A comment: when she was 'serious' she seemed to apply herself and engaged seriously to gain the necessary understanding.*] I also made use of my studies time, you know we got those [timetabled study periods] … I make use of them, make sure that… something that I have to understand I understand.

9.3.3 Study is not a dominant priority

The hallmark of this category of study prioritization is that the student is interested in things other than study and has little motivation to do anything more than what is necessary to get by academically. The activity of studying is not near the top of this student's list of priorities. A second reason why study is not a dominant priority for such students is that their general disposition is to enjoy life and to prefer doing things only when 'they are fun' or stimulating. In the case of the two students who exemplified this type of study prioritization both were avid sports-people, one was very socially oriented –a self-confessed joker who enjoyed 'messing around' – while the other was self-confessedly lazy unless he found the context to be stimulating. An addition feature of this category is that of being intellectually strong so that the student is able to learn quickly when they do manage to get down to studying. In this respect, this category is similar to the previous one in that the student is able to achieve at least satisfactory grades with a minimum of effort. The following extracts illustrate these points.

> I sat the night before the exam and read the entire textbook… *Okay… And that was all your engagement with [the subject]?* Yes. [E/2*] And sitting in lectures?* Some of them., usually doing different work though… Like I got so bored with [the subject]… like... honestly I was just... terribly, terribly, terribly bored. [Pause] But it worked out fine reading the textbook. *What did you get for the test?* Uh 75% [*Both laugh*] [E/2]

> School chemistry I didn't feel that challenged honestly. The ad-maths I found was more challenging but fun. I wasn't exactly the AA student. I understood a concept I would apply it and usually get between 70-80% which was fine for me. I didn't really go that extra mile of learning every little detail off by heart. … Well I never glorified marks. And maths I just enjoyed doing questions in maths. [E/1]

The above extracts and the one below also illustrate some additional dispositional characteristics of this type of study prioritization: the lack of application to hard work; the tendency to become bored easily if a lecture or course is not stimulating and challenging; a temperament that makes the student easily distracted from study by more stimulating activities; and a relatively low level of discipline when it comes to persevering in study. The latter two points are illustrated by the following extract.

> Like yesterday I thought, "Oh I'm going to go home and start studying a bit for [a particular subject]" cos we have a test on Monday. And then friends came over, and it's like, no let's go to the movie, and then… they went to the pub first and then to the movie… and then to the bowling club and then to McDonalds and you know like, it all just… carries on… *So you get pulled into distractions?* I guess. I think I want to be pulled into distractions… because it's like I am not refusing. [E/2]

9.3.4 Study is a declining priority

The characteristic feature of this category of study prioritization is a general decline in the level of commitment to study that is the result of flagging motivation, interest or persistently poor academic performance. Of the four students who manifested this kind of slippage particularly strongly (students B, E, G and AC), one talked about 'giving up' but persevered with a sort of resigned doggedness; one had a naturally depressive temperament that reacted negatively when his marks were significantly lower than the high standards he had set himself; and the other two lost interest in the programme of study they had registered for.

9.4 THE SCHEDULING SIDE OF LEARNING MANAGEMENT: SCHEDULING ORIENTATIONS

When examining the data related to the themes in Table 9.2, three observations were made with regard to the students' scheduling practices. First, scheduling was an important feature of each of the learning management activities in the table and, second, the nature of the students' scheduling practices was determined primarily by their organizational disposition and skill – how they organized their work in general – and by their level of discipline. Some students were organizationally strong and well-disciplined with regard to sticking to schedules they had developed while other students were organizationally sloppy or casual and rather ill-disciplined with regard to keeping to a schedule. Thirdly, all the scheduling of the students derived in the first place from the schedule of tutorials, practicals, tests and examinations imposed by the teaching and learning context with its set timetables and hand-in deadlines. All students, whatever their personal scheduling practice, worked off this externally-imposed schedule in some way.

The variation in the ways the students related to or were oriented to scheduling their work can be described in terms of the following four categories.

9.4.1 Ad hoc Scheduling

Scheduling is implicitly disordered and ad hoc with respect to time management (allocation of study time is ad hoc, study is frequently avoided and the student is easily distracted from it). In addition, scheduling is ad hoc with respect to study management, i.e. the selection of subjects to study is ad hoc. The only regularity evident in this category of scheduling practice derives from the externally-imposed schedule described above.

9.4.2 Loose Scheduling

In this category, in addition to working to the externally-imposed schedule, a general schedule is used that allocates study time during the week. However, the specific subjects to study and sometimes even the planned duration of study sessions are only loosely scheduled if they are scheduled at all.

9.4.3 Affectively-driven scheduling

In this category, a student's schedule is affectively determined. If their general scheduling is ad hoc in nature they work when they 'feel like it' and on the topic they 'feel like studying'. If they follow 'loose scheduling' practice, the topics they choose to study during scheduled study times are the topics they 'feel like' studying. This is demonstrated in the following extract.

> *Did you have a work schedule?* No, I didn't. I didn't. Whenever I just thought like I need to study, that's the time I do that. [S/1]

9.4.4 Careful Scheduling

Compared to loose scheduling, this category of scheduling practice allocates time, topic and duration of study in a more meticulous, thought-through and thorough manner. In addition, it also schedules other

aspects such as test preparation, catching up, and 'me time', i.e. time spent 'on me' (Student A) such as socializing, exercise, rest, etc.

9.5 THE VARIATION IN STUDENTS' LEARNING MANAGEMENT PRACTICE

The analysis of the ways students reported going about the management of their overall learning effort identified five categories of learning management practice:

Keeping deadlines
Keeping at it
Keeping up
Keeping ahead
Keeping on top

Each of these categories is described and illustrated below.

9.5.1 Keeping deadlines: basic learning management practice

All categories of learning management practice include the goal of keeping required deadlines – making sure that required work is completed more or less on time and that studying is organized on the basis of the deadlines imposed by the dates of tests and exams (the externally-imposed schedule described earlier). However, the characteristic of this category – a 'basic learning management practice' – is that the 'keeping of deadlines' is the *only goal* of the management practice. This is the consequence of a disposition that perceives study as being neither a dominant nor a demanding priority. The resultant scheduling practice is ad hoc in nature, and work and studying is typically left to the last minute.

9.5.2 Keeping at it: the 'work-hard' learning management practice

In this and all the following categories of learning management practices, study prioritization and study effort are of the kind where study is the chief priority and the student 'works hard' – they put in considerable effort to study and learn, or, put differently, they 'keep at it'. However, what characterizes this category of learning management is the perception that 'working hard' is the primary issue – even the only issue – driving the management of the studying and learning effort. As one student put it, "everything comes with hard work" [H/2]. Consequently, the characteristic intention behind this category of learning management is to be 'keeping at it' and the study effort is seen essentially in quantitative terms. For example, if someone operating with this type of learning management practice were questioned about what should be done to improve academic performance their typical response would be to say, "I need to work harder" or longer. The following extract illustrates the point.

> But the thing is that it's not like I'm not studying. I am … I'm just not studying for long enough and I'll study for five days before [the test] instead of the two weeks that we've known about it. [B/2]

The next extract highlights the quantitative view of hard work by contrasting it to the more qualitative perspective of 'working smart'.

> I think I'm socialising more and um working less but I, I don't feel so, um, worried about it. Before I would do every single example and that's like a bit stupid. That's working hard it's not working like smart. It's not like I'm not working at all. I am working but I'm picking out the hardest examples and doing them. [A/2]

Study scheduling associated with the practice of 'keeping at it' is somewhat variable in nature but the data is not very clear in this regard. It seems that, with regard to time management, scheduling is not ad hoc (the commitment to studying mitigates against avoiding studying and limits vulnerability to distractions) but it may be ad hoc with regard to subject selection. With regard to the other management categories in Table 9.2, scheduling may be affectively driven, and, in general, is probably loose and not 'careful' in nature as described in that table.

9.5.3 Keeping up: diligent learning management practice

This category of learning management practice is characterised by the goal of 'keeping up'. Here, there is an awareness of a need to be diligent in working and studying in a way that keeps abreast of the course material in addition to the basic requirement to be 'keeping deadlines' and 'working hard'. The emphasis is not so much on striving to master the material but on at least developing and maintaining an up-to-date level of familiarity with the material as it unfolds in the course. As the following two extracts illustrate, the primary feature of the practice is consistency and regularity – the need to be keeping up on a daily or weekly basis; put another way, a careful scheduling of the learning effort is necessary.

> You know, I had to kind of keep up with all of my subjects, not necessarily do the work every day, but just… keep up, a sort of basic understanding. [AA/2]

> *And what would you tell them about how to go about learning and studying?* Learning and studying… consistence. They must be consistent, you know, keep up to date, especially with the maths. [AE/2]

The next extract is an illustration of how the practice of 'keeping up' can operate in the larger context of the student's study and learning effort. It also illustrates how the practice intersects with keeping deadlines and how it involves adapting to the demands of the context. In this extract, the student indicates that, at school, he had been able to keep up 'in his spare time' but, in the more demanding learning environment of university, he had found it necessary to work to a more intentional schedule that involved both a daily and weekly effort to keep up.

> I'm still adapting but then the ways I used to study and go about my work last year [at school] it's totally different to what I've been doing for the past five weeks because, ok, here you learn a lot, the work load is a lot and then every night it would be like – just last year I'd go through the stuff whenever I had spare time, but then here in varsity I go through the things like the day I learned them. And then during the weekend that's when I go through everything that I've learned to see if I understand it, and you also have to prepare for the coming week [in terms of assignments and pre-labs and reading ahead] … It's a lot of work here. [L/1]

The final extract in this section gives details of a typical strategy for keeping up and also illustrates the foundational awareness that is inherent in this type of learning management practice – effective learning is incremental in nature and simply keeping deadlines and working hard is not enough.

> [My biology teacher] told us every day, instead of waiting until three days before the test, just learn bit by bit and try to do, you know, per day, do what she did in class, because your memory is still fresh, you still understand it, when you read the text book you know what they're talking about. So she explain the thing thoroughly in class then you have to go and get the text book and study the thing. So, she said instead of us studying 20 pages before the test, it's better to do it bit by bit. And the understanding is more because before the test you're actually cramming, you're not even studying. [K/1]

9.5.4 Keeping ahead: anticipatory learning management practice

This category of learning management practice is characterized by the goal of 'keeping ahead' of the delivery of course material in some way. Here there is an awareness of the benefits of going into a lecture having previously developed some idea of what that lecture will be about. The standard strategy is to anticipate or find out what will be presented in upcoming lectures (typically from the course schedule) and then to read ahead of time the relevant sections of the textbook. The following extract illustrates this practice and its perceived benefits. It also illustrates how the development of the practice was an important factor in the student becoming much more confident about her ability to cope with lectures.

> Okay, something else that is giving me confidence I think is the fact that… I am well prepared when I come to lectures, I think. And I make sure that I am on the same track with the teacher, so that also gives me confidence in myself, because, if I don't do this, I am just going to panic and end up messing everything up. *So, you are coming to lectures well prepared now?* [Yes] *Tell me about that.* I just … uh.. browse through the chapter even if I don't really, like, understand, just to get uh, uh, uh, more basic knowledge about what is going to happen there in class. [R/2]

A related practice that is less explicitly keeping ahead is to prepare for upcoming lectures by reading over what was covered in previous lectures. The following extract illustrates the practice and also how it was combined with other strategies for keeping ahead of what was going on in class.

> *Preparing for classes in advance?* I try as much as possible. *How would you do that?* Reading through previous notes, so that the next time that we are carrying on, so that I am not completely lost I know how it carries on or … sometimes I'll prepare for, um tuts and well in advance and… the night before read through the tut or read through, read through whatever I can to prepare me for the next [lecture]... other times you don't know what's going to be in the next lecture so there is very little you can do. *How much time do you spend doing that?*... during the week I will try to allocate about an hour to a different course, where it's just like, its revise. Revise what happened today. [W/1]

The next extract is from a student who, like the first student quoted in this section, found that the development of the practice of keeping ahead revolutionized his learning and was a major reason for the improvement in his academic progress. The extract also illustrates how the practice was combined with the practice of keeping up.

> Okay, it developed when, after I found out that I have to prepare myself before a lecture, and then I'll go to there and take the notes from the lecture, some of them what the lecturer is saying and what he has wrote - I mean the examples - take the problem and answer and understand which I will find will help me, which I don't know about those things. [AD/2]

In effect, keeping ahead is an advanced form of keeping up and requires extra effort because an additional learning activity is required. This also adds to the factors which scheduling must take into consideration.

9.5.5 Keeping on top: comprehensive learning management practice

This category of learning management practice is characterized by the goal of 'keeping on top'. Here, the student is motivated not only by the awareness of the need to be 'keeping up', 'keeping at it' and 'keeping deadlines' but also by the intention to not only master the material covered but to do so in a way that keeps such mastery abreast of the course as it unfolds. Study prioritization, scheduling and effort management are of the same kind as in the two previous categories.

The following collection of extracts from student A illustrates this type of practice. Rather lengthy extracts have been presented in order to convey the full sense of the intention behind the practice. In the case of this student, the intention to 'keep on top' was almost a compulsion.

> *[This] sense of security [you were talking about] was it because you felt you weren't going to be tripped up by some question?* Yes. Well basically I prepared [for tests] as best as I could. *So you felt secure because you were well prepared?* Yes. *Can you think of a time when you weren't well prepared?* Umm…yes, there have been a couple of times where you walk into a test or you walk out of a test and you still feel like you didn't grasp a certain concept well – yes, it's not a good feeling. *What did you do … after that…?* Go home, look it up, see what it is. *Do you always do that?* Yes, I do. *And why did you do that?* I like staying on top of everything, and when I found something that I didn't go over I was kind of like, you feel bad because you think ok, you didn't prepare as well as you should have. But also there are times like it's good that you see stuff because then you know there's always more that you can do even if you got it right. [A/1]
>
> *How important…* Is it to be on top? *... How important is it for you to understand it and know stuff, rather than just being well prepared?* I think it's both of those things, to be well prepared and to also know more than what you're expected to know. *... To what extent is it because, 'well I just like to know'?* I think it is that, it's a nice feeling when you're learning things just for yourself. There's lots of times you open up something, you're reading just to know what that's about. *So did you do that quite a lot?* Yes, I did, because lots of times text books will make a reference to something that we haven't done or not going to do and then you look it up and you see what it's about just to know. *Did you do that quite a lot?* Yes, when I had time obviously, but it was very quick, like, just … read … you know. [A/1]
>
> Like my first week I just wanted to tear my hair out because, like, I said I like being on top you know, of what I'm doing, and this was just like deep end, sink or swim, and I'd forgotten all the stuff from matric, so just basically like I had to go back home and revise maths and science from matric. [A/1]

9.6 LEARNING MANAGEMENT PRACTICE: THE OUTCOME SPACE AND ITS PEDAGOGICAL IMPLICATIONS

The outcome space from the analysis of student statements about their learning management is summarized in Table 9.3 below and its structural features are discussed thereafter.

Table 9.3: Variation in Learning Management Practice: The Outcome Space

	Category	**Characterizing Feature**	**Study Prioritization** (see section 9.3)	**Scheduling Orientation** (see section 9.4)	**Intention of the Learning Management Practice** (see section 9.5)
1	Basic	Keeping deadlines	Not a dominant or a demanding priority	Ad hoc or affectively-driven	Does not extend beyond keeping the deadlines imposed externally by course schedules.
2	Working-hard	Keeping at it	Chief priority	Loose or affectively-driven	Does not extend beyond the amount of effort expended.
3	Diligent	Keeping up	Chief priority	Careful scheduling	Keeping up at least a basic level of understanding as the course unfolds.
4	Anticipatory	Keeping ahead	Chief priority	Careful scheduling	Keeping ahead of the course material as it unfolds.
5	Comprehensive	Keeping on top	Chief priority	Careful scheduling	Incremental mastery as the course unfolds.

The structure of the outcome space presented in the table shows that the five categories of learning management practice (keeping deadlines, keeping at it, and keeping up, ahead and on top) correspond to a progression from less to greater levels of sophistication or commitment with regard to degree of

organization and discipline, and commitment to studying and to incremental learning. The critical aspects of the variation are study prioritization, scheduling orientation, and intentionality (the intention behind the management practice, i.e. the intention to keep deadlines, keep at it, up, ahead or on top). The first of these aspects – study prioritization – embodies the effects of many dispositional elements including self-confidence, motivation, temperament, self-discipline, work ethic, organizational disposition, attributions, and reasons for studying. There is variation in each of these elements which, taken together, shape whether study is prioritized as a non-dominant or a non-demanding priority, or as a chief priority or a declining priority. The first two of these categories of variation correspond to a problematic level of commitment to studying that typically translates into the learning management practice of merely keeping deadlines. Consequently, constraints to learning can in principle be identified in each of the elements affecting study prioritization by investigating the variation in those elements and how that variation is related to study prioritization. This has not been undertaken in this study, but the interview data suggests that two elements in particular seem to be important – motivation and self-confidence.

The second critical aspect of the variation is scheduling orientation. The elements which shape this aspect include attributes or capabilities (for example, organizational ability), dispositions (for example, self-discipline), and conceptions (for example, conceptions about the importance of being organized, and awareness of one's organizational capabilities and preferences). There is variation in each of these elements which, taken together, influence whether scheduling is ad hoc or loose in nature, or whether it is affectively-driven or more carefully, systematically, and comprehensively planned and executed. Two distinct shifts are evident in this progression. The first is from ad hoc scheduling – little or no scheduling – to loose scheduling where schedules are used but are somewhat disordered or haphazard. Ad hoc scheduling constrains learning because it is does not create and maintain an appropriate space and timeframe for regular study. The second transition is from affectively-driven scheduling to careful scheduling. Here the transition is associated with becoming more systematic and thoughtful about one's scheduling practice with obvious implications for learning.

The third and perhaps most critical aspect of the variation is the intention behind the learning management practice. The elements which shape this aspect consist of three types of conception.

- Conceptions about the kind of space and the amount of time needed for effective study. These affect scheduling priorities in general and are derived from conceptions about mastering-practice and test-focused study practice.
- Conceptions about whether knowledge is quantitative or qualitative in nature. Viewing knowledge in quantitative terms constrains learning because it predisposes a student to the practice of *keeping at it* rather than employing the more sophisticated practices (*keeping up, ahead* and *on top*) which recognize the efficacy of incremental learning.

- Conceptions about the nature of learning, combined with a qualitative conception of knowledge, influence the degree to which a learner is aware of the nature and importance of incremental learning and, consequently the need to be keeping up, keeping ahead and keeping on top.

CHAPTER CONCLUSION

This chapter has presented the study findings in regard to the learning practices associated with the contexts of preparing for tests and managing one's overall study and learning effort. These findings complement those related to the context of focusing only on the mastering of the requisite understanding and skill. Chapter 11 draws these findings together and discusses their broader pedagogical implications. Before that however, the next chapter addresses the issue of how learning practices change.

CHAPTER 10: DATA ANALYSIS AND RESULTS 5: CHANGES IN LEARNING PRACTICES

The previous four results chapters reported the findings of the analyses that focused on addressing the first research question, *"What is the qualitative variation in the students' learning practices on entry to university?"* For each of the various types of learning practice that were analysed a set of categories was developed to describe the variation that had been identified.

This chapter, the last of the five results chapters, marks a shift in the focus of attention to the second and third research questions. The second – *"What is the qualitative variation in learning practices our students develop during their first year of study?"* – has largely been addressed in the previous two chapters, albeit inadvertently; the variation in those aspects of learning practices that were investigated in those chapters was the same at the end of the year as at the beginning with the exception of note-taking practice. To be sure, the practices of many individuals changed but not to the extent that qualitatively different types of practices emerged. The one exception to this was the emergence of a new type of learning practice that had to do with engagement with verbal instruction in the classroom.

The third research question – *"In what ways do our students perceive that their learning practices have changed during the course of the year?"* – involves the issue of change in practices. This chapter focuses on this issue.

10.1 OVERVIEW OF THE CHAPTER CONTENT

How students changed their learning practices was investigated to gain insight into dynamics that might affect interventions intended to help students to change their learning practice. The investigation was guided by questions such as the following. What proportion of students changed their practice? To what extent did they change? If change occurred, when did it happen in the year and what prompted the change? Did the level of practice of a student on entry have a bearing on the extent and nature of change? What sort of change processes operated during the year? If no change occurred, why was that?

Only two aspects of learning practice were investigated from the perspective of change – theory-focused study practice (a key aspect of mastering-practice) and classroom practice (that is, engaging with formal verbal instruction to take notes and to learn by listening in class). Investigating the first gave insight into the changing of an existing practice while investigating the second gave insight into the development of a new practice.

Part A of this chapter reports on the first investigation. The data analysed was derived from two sources: the students' perceptions of how they had changed during the course of their first year of study; and a comparison of the level of practice of individuals at the beginning and end of that year. Part B reports on the second investigation which focused on the development of new practices – specifically, note-taking and listening-to-learn-and-understand while taking notes. The investigation was conducted in two stages. The first focused on identifying the qualitatively different categories of practices which the students developed. The second used these categories as a basis for interpreting student reports on how their practices changed. Part C concludes the chapter by comparing and contrasting the findings from Parts A and B and discussing the significance of what was found.

PART A: CHANGE IN AN EXISTING PRACTICE: EG: THEORY-FOCUSED STUDY PRACTICE

All the students in the study came to university with a particular theory-focused study practice which they had developed at school. This part of the chapter reports on the investigation into how that practice changed during the first year of their study at university. The investigation focused on two aspects of change – its extent and the dynamics which affect change. These aspects are reported separately.

10.2 THE INVESTIGATION INTO THE EXTENT OF CHANGE

The extent to which individual students changed their theory-focused study practice was investigated by comparing the levels of their practice at the beginning and end of the year. The levels of practice were evaluated on the basis of the categories of variation established in Chapter 6. As reported there, it was found possible to characterize an individual's theory-focused study practice by identifying the highest level of sophistication which their practice had reached as interpreted from their interviews. The levels of practice of individual students on entry to university were evaluated by interpreting their statements on how they had engaged in studying and learning at school. Their levels of practice near the end of the year were evaluated from their statements about the nature of their study engagements at the time.

For each student, the extent of change in their practice was gauged by the degree to which their practice appeared to have shifted from one category to another. Four types of change were evident and were labelled 'no change', 'minor change', 'adapted', and 'shifted'. 'No change' speaks for itself. Changes labelled as being 'minor' were ones in which the small degree of change reported by a student was considered by the researcher to have involved only their adjustment to the teaching and learning environment and not a discernible change in the study practice itself. Changes labelled as 'shifted' were those where a student's practice had 'shifted' from one category or subcategory of practice to another. Change labelled as 'adapted' is an in between category where some change was clearly discernible but did not involve a shift from one category of practice to another; it consisted of

discernible change within one category of practice. For example, several students with a consolidation level of practice on entry did not shift to another category but reported that they paid more attention to understanding at the end of the year than at the beginning.

10.2.1 The findings

For convenience the five levels of theory-focused study practice were coded SP1 to SP5 (Study Practice level 1 to 5) which correspond respectively to information-, comprehension-, consolidation-, refinement- and know-how oriented practice respectively. The study practice of several students appeared to lie somewhere between these categories either because the data was unclear or because some students reported having had some experience at a level of practice more sophisticated than the one at which they tended to operate. In such cases, the researcher's discretion was exercised to represent the actual level of practice as appropriately as possible – either at the less or more sophisticated level or as somewhere between.

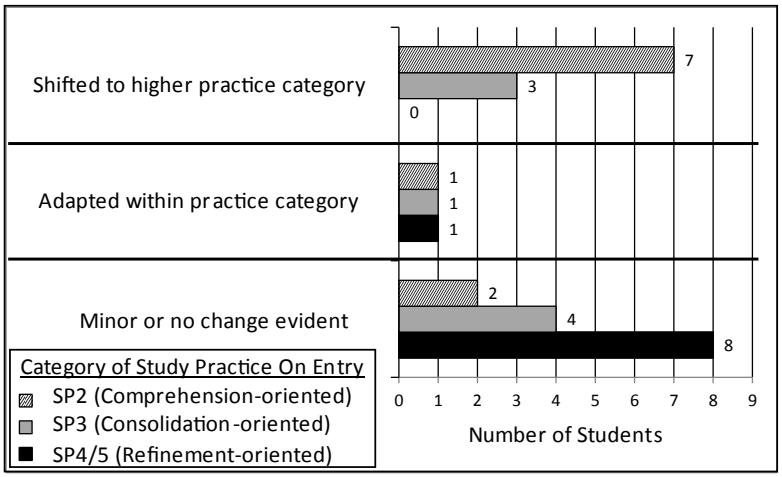
With four of the students in the study, nothing conclusive could be drawn from the data in regard to the extent to which their practices had changed: student V withdrew from the study after the first interview; the data from students E and O was distorted by the nature of their study prioritization; and, as explained in Chapter 5, the data from one student had been discarded as being generally unreliable. With regard to the remaining 27 students, it was possible with19 of the students (70% of them) to corroborate the researcher's evaluations of the extents of change with the students' reports. Only in the case of 7 students (25% of them) were the conclusions drawn exclusively from the researcher's interpretations of their levels of practice at the beginning and end of the year.

Of the 27 students for whom a reasonable evaluation was forthcoming, 10 (37% of them) shifted their practice, 3 students (11% of them) adapted their practice but did not change category, 2 students (7%) appeared to change in only minor ways, while 12 students (44% of them) did not appear to change their study practices at all. Interestingly, one student (student J) adapted his practice by trying out some of the strategies recommended in class. However, after finding they 'didn't work for him', he intentionally reverted back to the practice he had used at school.

Figure 10.1 breaks the results down further to explore the extent to which students who entered university with a particular category of practice changed that practice. The breakdown is presented both in the form of a bar chart and as an accompanying table – the information in both is the same.

The figure indicates the following. Ten students entered university with relatively unsophisticated study practices – up to and including comprehension-oriented practice (SP2 and SP1/SP2 categories) – and had much scope for improving the quality of their practice (they could progress to levels SP3, SP4 or SP5); it was important for them to do so if they were to improve their academic prospects at university. Of these 10 the majority (7 of the 10) shifted their practice, one adapted but two did not

appear to change their practice at all. However, in all but one case, the extent of change involved only a shift to the next most sophisticated level of practice.



Practice Category On Entry	Number of students in each change category		
	Minor or no change	Adapted	Shifted
SP2	2	1	7
SP3	4	1 adapted & reverted	3
SP4	8	1	0

Figure 10.1: How Students (with Different Study Practices on Entry) Changed Their Practice

At the other end of the spectrum, 9 students entered university with relatively sophisticated study practices – up to the level of refinement-oriented practice and also those with some know-how oriented dispositions (SP4, SP3/SP4, and SP4/SP5 categories) and did not have as much scope for improving their practice (they could only progress to SP5). The majority of these (8 of the 9) did not change their practices or made only minor changes and only 1 adapted their practice.

Between these two groups of students were those who entered university with an intermediate level of study practice – practice up to the level of consolidation-oriented practice (SP3 and SP2/SP3 categories). Here, the scope to improve their study practice was still substantial – they could progress to SP4 and SP5. Of the 8 students with this profile, only 3 shifted, 1 adapted (and then reverted to his old practice), and 4 did not appear to change or only made minor changes to their practice.

10.3 THE INVESTIGATION INTO THE DYNAMICS OF CHANGE

This investigation focused on the data gathered to address research question (c). This data consisted of the students' responses to questions about how their learning practices had changed from school to university and then through their first year of study at university, how they perceived they had changed, why they had changed and when, and what had prompted them to change. As in the previous investigation, the analysis of change was addressed only from the perspective of the students and the findings were based only on what students reported in their interviews. The findings from the investigation into the extent of change were incorporated in the analysis so that as full a picture as possible could be obtained about the nature of dynamics associated with changing learning practices.

10.3.1 The findings

Change in learning practice was evident with only 15 students and, of these, 2 had changed little, and 3 had 'adapted' their practice. Accordingly, data from only 10 students was available to give indications about the dynamics behind shifts from one category to another. Consequently, the conclusions drawn from the investigation must be considered tentative. They are as follows.

a) *The extent of change appeared to be limited to crossing from one practice category or subcategory to the next most sophisticated*. This was the case with 5 of the 10 students who shifted their practice. The study practices on entry of 4 of the 10 students were between two adjacent categories and the change appeared to involve moving more fully into the more sophisticated practice.

b) *Most students who realized they needed to be serious about changing their study practice seemed to take about half the academic year to reach this conclusion.* Of the 15 students who indicated they had changed their study practice in some way – minor change, adapted or shifted – only 5 started to do so in the first semester. Of these, 2 were making only minor changes to their practice, and 2 were responding to class input.

c) *Few students shifted their study practice as a result of class or textual input on the subject*. Of the 13 students who shifted or adapted their practice, only 3 did so as a result of formal input in class and 1 as a result of received a faculty newsletter on study skills.

d) *The primary driver of change in study practice appeared to be the stress created by getting poor grades and the student's recognition that their current study practice wasn't 'working for them' in the sense that it was not facilitating the achievement of satisfactory grades.* Even in the case of the four students who responded to formal input on study practice, two of them appeared to be responsive because their current practice was not working for them. Of the 13 students who adapted or shifted their practice, only 3 were not pushed by marks pressure to change their study practice. Two of these took their lecturer on trust and started using recommended study strategies. The other, student I, made the change through a 'eureka experience' of discovering the efficacy of using summaries effectively when preparing for a mid-year supplementary maths examination.

e) *Poor performance in the first semester appeared to be far less of a change driver than poor mid-year marks.* Of the 9 students who were pushed towards change by pressure directly or indirectly because their practices 'were not working for them', only 2 did so on the basis of poor performance in first semester tests and assignments. For the other 7 it appeared to take poor performance in what they perceived to be their 'major' assessments – namely, the mid-year examinations – before poor grades had the impact of pushing them towards change. The following extract gives other reasons why poor performance in the first semester did not seem to have the impact of poor performance at mid-year: the student felt she could still catch up; she was still adjusting to varsity; and she didn't realize that it was her study practice that needed to change.

> Ok, I changed when I come back now, the 2nd semester, cuz I've seen already … the way I am studying it was not working. … There was something serious that needs to be done or else I am just going to end up regretting. Ja. *You didn't realise that after the first set of tests after the 1st quarter?* Not really. *Why was that?* I think it's because I used to tell myself that I'm going to catch up ... [But] I've been trying to catch up and still it's not working. So now it's like, ok. *You did have results at the beginning of 2nd quarter.* Ja, I did have results but I just thought … I'm just adjusting to varsity life, all those things [laughs] and then I can see that no, it's actually the way that I am studying, it's not really that effective. *So it took until mid-year. What made you realise that it wasn't working?* Cuz I was still not progressing. *By progressing, what were you looking at?* I'm looking at passing as a whole, you find that some of the things I am passing, but not … really that much even though some I was failing like really failing, but now, since I have started practicing these things [the new practices], that's why I have so much hope and so, so much confidence in myself cuz I've seen that it's working [in] the second [semester]. I am actually passing and I thought I was never going to pass like that. [R/2]

PART B: DEVELOPMENT OF NEW PRACTICES: EG: CLASSROOM PRACTICES AT UNIVERSITY

In this part of the chapter, the focus of attention is the learning practices associated with verbal instruction received formally in the classroom. In this regard, the teaching and learning environment in the university classroom is markedly different from that in the school classroom and, consequently, the students had to develop new learning practices: in particular, the making of notes during lectures and learning by listening while taking notes. To investigate how these practices developed over the year, an approach similar to that described in Part A was adopted: qualitatively different categories of practices were identified by analysing student descriptions of their practices; the extent of change in their practice was characterized in terms of shifts from one category of practice to another; and the dynamics of the processes associated with the development of new practice was investigated by interpreting students' descriptions and perceptions of those processes. The three aspects of the investigation are reported separately. The significance of the findings from the three aspects of the investigation is discussed in Part C.

10.4 THE INVESTIGATION INTO THE VARIATION IN CLASSROOM PRACTICE AT UNIVERSITY

Verbal instruction is a major component of the education system both at school and university where the intention is that students will listen actively and, at least in some measure, will learn by listening to that verbal input. In the experience of the students, it was clear that such *listening-to-learn* – simply listening to the teacher in class – was a major component of the educational system at school. However, while *listening-to-learn* was far from a new activity for the students, the context of having to do it quickly and accurately enough to enable meaningful note-taking was new.

While it appears to have been a common experience for many of the students of copying notes a teacher had written on the board at school, only two students indicated that they had had any experience of taking notes from verbal input prior to coming to university: student S had regularly taking notes during sermons at church; and student B had developed the practice of taking notes at school to reinforce learning but not as a means of capturing information.

The inter-twined nature of listening in class and note-taking complicated the analysis of the variation in the students' classroom practice. Although it was possible to identify the variation in the ways students related to each of these activities, considerable overlap was found in each case, so that variation in the one could not be properly described without reference to the variation in the other. The dilemma was resolved by recognizing that the students were not so much relating to the phenomenon of listening in class or to the phenomenon of note taking as they were relating to the phenomenon of engaging with volumes of important information that was presented to them verbally. From this perspective, listening and note-taking were simply the strategies they used to engage with the verbal input while the intention behind their engagement was some balance or trade-off between capturing information and listening-to-learn. The following analysis of that trade-off is couched in terms of the practice of note-taking.

10.4.1 Variation in note taking practice

The methodology used to investigate the variation in the note-taking practice of the students in the study was the same as before except that transcript fragments relating to two types of activity were examined – listening in class and the making of notes. The analysis identified five different ways in which students related to and engaged with verbal input: capture everything, capture the outline, capture the main points, capture what's new, and capture nothing just listen. These category labels derive mostly from the perspective of note-taking – that is of capturing information. Implicit in this labelling scheme is the awareness that less attention given to capturing information implies more attention given to listening-to-learn. This trade-off is explained in the descriptions of each category that follow and is also summarized graphically in Figure 10.2.

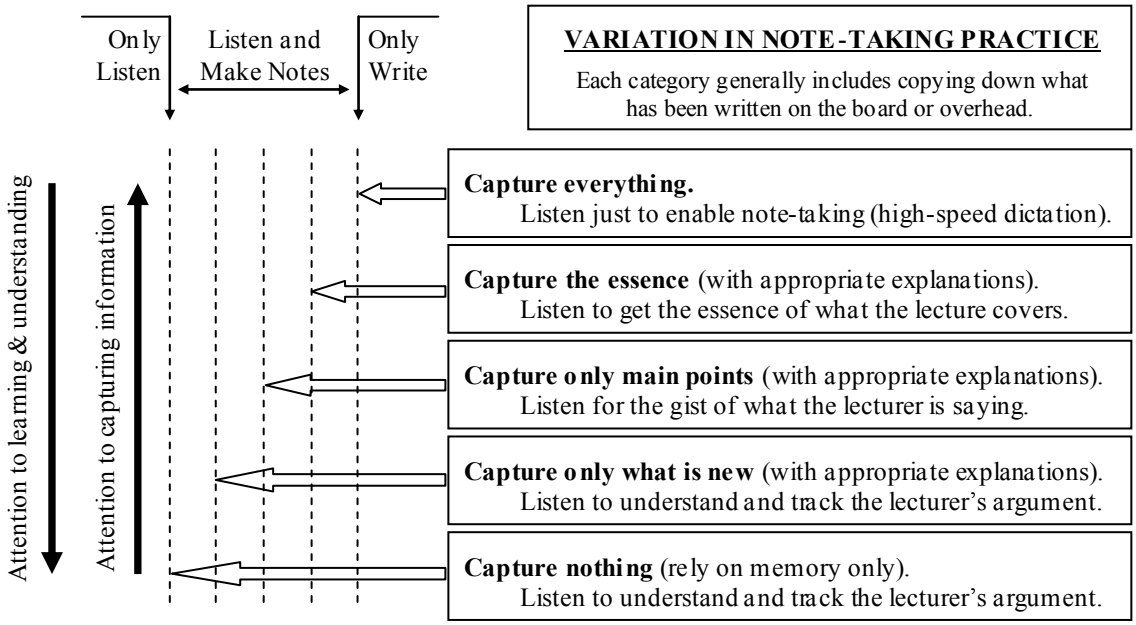


Figure 10.2: Variation in the Practices of Listening and Note-Taking: The Balance Between Listening-to-Learning and Capturing Information

10.4.2 Capture everything

This category of note-taking practice majors on information capture to the extent that listening-to-learn suffers. The intention behind listening is predominantly to hear the information that needs to be captured and to write it down. As the following two extracts illustrate, the practice requires the ability to write fast as though one is taking high speed dictation, and it involves a minimal engagement in listening to understand with the result that the student learns little during the lecture and doesn't properly hear what the lecturer is saying.

> *How much do you learn when you're taking notes?* I don't … I just write. Cos I write really fast - I try and capture everything that the person is saying and then hoping that at the end of the day I'm going to read it. [B/2]

> *Taking notes - how are you with that?* Um… I suppose, I don't really listen that much, or as well as I think I should because I am focussing on writing down what's on the board because if you miss [something] … you just have to get down what's written... like… quickly. And then at home you have to go through it by yourself. See if you understand. [I] don't listen that much cos [I'm] taking notes. ... *That means that you're not picking up that much.* Ja from what like the lecturer is actually saying. ... I think I should actually be listening [more] … like writing down not as much. … When I write down like every single thing that's written on the board I don't pay attention to what the lecturer is saying properly. [K/2]

The second extract demonstrates not only the 'high-speed dictation' mode of note taking but also the experience of having to postpone the effort to understand the material until sometime after the lecture.

10.4.3 Capture the essence

This category is not concerned to capture everything that is said during a lecture but only its essence – the core of what was said and done but without all of the detail. In order to be able to do this, the student must listen in a way that develops sufficient understanding of what is being said that they are able to identify what that essence is. As the following extracts illustrate, the result is a smaller volume of notes that are a summary or outline of what transpired in the lecture. The notes taken are more concentrated but contain what is important for the student to know including any tips or personal understandings reached during the lecture.

> *Tell me about how you take lecture notes?* … my lecture notes is just the summary of what the lecturer talked about in the lecture. Cuz I don't take down everything … for me, the way I learn, I listen and then when I listen its part of the learning process for me. To listen and then just make a summary … and then I go back home … The lecturer will… talk about this and then, I just write, I won't write everything in detail the way the lecturer tells us. … I will just write, you know, bits and pieces of what the lecturer tells us. [L/2]

> I kind of generally focus on the more important stuff, cuz looking back on what I took down at the beginning of the year. A lot of the time I took down stuff that wasn't important. So. The volume of notes has gotten less, but, I'd say it's more concentrated and, what's more important, the important stuff is there. [C/2]

> *What do you do in lectures?* Oh, I follow what the lecturer is saying first, then I copy, whatever, I make side notes of what he says we should take note of… Sometimes I take down my own notes – my own understandings – in lectures. And the whole thing of listening and understanding. [D/2]

Together these extracts illustrate a practice in which there is a balance between capturing the important information conveyed in a lecture and developing some level of understanding of what is being verbally conveyed.

10.4.4 Capture the main points

This category of note-taking practice takes the previous one further in the direction of capturing less information and concentrating more on understanding what is conveyed. It aims to capture only the main points of what was said rather than the essence of all that is said in a lecture. As the following extracts illustrate, this requires the student to listen even more carefully in order not only to be able to distinguish and understand the essence from everything that is said but also to be looking specifically for the main points and key concepts being communicated.

> *The big problem obviously is writing and understanding.* Ja. *Talk to me about that.* I can't do both at the same time. That's why my notes are main points now, cuz, I tried [to] first hear what the lecturer is explaining and, try to like … understand it, and then from there I will put my understanding down. Whereas before [at the beginning of the year] I would write everything down and then go home. And try to figure out what I wrote, which is a waste of time, actually, when you could do it in the lecture. [A/2]

> When you're listening [in a lecture] there is some things which you know that you have to take down. Ja. *How would you know what those things are?* When [the lecturer] says it. … Cuz most of the time, it's explanation, explanation and then there is always a main point out of this whole explanation. *But the lecturer doesn't always tell you, "Here's the main point, write this down."* Uh you can tell sir. [pause] That's one thing we've learnt … as time went by. That not everything they say is actually the main point. [J/2]

The second extract is particularly interesting because it describes a clear process which the student has developed that is attuned to listening to and understanding the general explanations and, at the same time, listening for the main point and being alert to identify it and note it down when it comes. This contrasts to 'capturing the essence' which involves a more generalized listening practice and a note-taking practice that is more akin to writing a précis of what is said in the lecture. The second extract is also interesting because it alludes to the dynamics associated with the development of the practice of 'capturing the main points'; in essence you pick it up from experience.

10.4.5 Capture what's new

In this category, a further level of discernment is applied when listening to what is said in a lecture. Now, the student concentrates particularly on capturing what is new and intentionally leaves out what they already know. This reduces the volume of notes further and allows more time for listening and thinking about what is said in the lecture. The following extract illustrates the process.

> *Note taking in class. What's that like for you?* Uh, I find my note taking skills working for me because uh... I take down the main points or whatever, I find that whatever the lecturer puts on the board basically is a main point and while the lecturer is speaking, things that I didn't know that other people had known. Uh, I'd just jot that down. But things that I do know I won't put that down on paper. [A/2]

10.4.6 Capture nothing – just listen

This category of note-taking is the direct opposite of the first; in essence it is to 'just listen' as opposed to 'just write and capture everything'. Students adopted this practice for one of the following reasons.

a) *It's what I am used to*: As illustrated in the extract below, for one student, learning at school involved simply listening to the teacher. Consequently, at university, the student 'just listens' because that is what they are used to doing.

> In the beginning of the year, honestly I was not used to writing notes so I was applying the thing I used to do in high school of just listening to the teacher and from this I go home. I just read the

> book and see; oh the teacher is talking about this and this. But here at university it seems very different. It does not work so you have to [take] notes. [Q/2]

b) *It's all I can usefully do*: In this case, a student finds that to both listen and take notes is so difficult to do that neither activity is performed effectively or meaningfully. The result is the decision to concentrate on just one activity and that would be to 'just listen'.

c) *It's what I prefer to do*: In this case, the student 'just listens' out of preference, reasoning that it is more important to understand as much as possible from what is said in a lecture.

The following extract illustrates the latter two practices. The student found his note-taking skills to be ineffective to the extent that it interfered with his ability to listen in class without the commensurate benefit of leading to usable notes. The student also had a phenomenal memory and a strong intellect and so, in any event, had a preference for concentrating on learning from what was being said.

> *Writing and listening at the same time, can you do that?* ... Writing and listening, I'm not good at it. I would rather listen because I can grasp more when I listen, and later on I can put it down on paper. If I focus more on listening … it has a greater influence in me passing than just take notes and not really focus on listening. So, ya. And if I take notes without much listening I tend to ask other people what we have been doing while I was in the class. That is why I don't take notes, I just listen … I write it later on. [AC/2]

10.5 THE INVESTIGATION INTO HOW NOTE-MAKING PRACTICE DEVELOPED

All the students struggled in the development of their note-making practice, even the few who came to university with some experience in the practice. How the practice developed and changed was relatively easy to analyse and describe once the categories of variation in the practice described above had been identified; the development of the practices of individual students could then simply be explained in terms of how they changed from one category to another. Again, the analysis is undertaken only from the students' perspective and from what they described of their experience.

The variation in the way the new practice developed is described in terms of four categories of developmental progressions. Each is characterized by a different sequence of shifts from one category of note-taking/listening-to-learn to another. The developmental progression of the students' practice began either by 'just listening' – their listening practice at school – or by trying to capture everything or a very full essence of the lecture. Four qualitatively different developmental progressions from these two starting points were evident.

a) *Progression sequence 1*: Here the student who starts by trying to 'capture everything' continues to do so but becomes more adept at it. In this case, the student learns to write faster; they develop somewhat in their ability to learn something from class while they are writing away madly; and their conception is that they will study from their notes after class and work on their understanding of the material then. Students who followed this path included students B, N, AF and, to some extent, student AB.

b) *Progression sequence 2*: This more common developmental progression is when the student who begins by trying to 'capture everything' and then, finding this to be somewhat futile in that they are writing too much and not understanding as much as they could, changes in the direction of writing less and concentrating more on 'listening to learn'. This progression ends up in either the category of capturing the essence or capturing the main points.

None of the students who followed this kind of developmental progression reported ending in the category of capturing only what's new. Student A (and possibly Student E) appears to have exercised the latter practice only sporadically their more regular practice being to capture main points.

c) *Progression sequence 3*: This type of developmental progression is when the student begins from the school listening practice – just listening – and then realizes that continuing with this practice will result in them quickly forgetting much of what they hear in class. Consequently, they change, in effect, to developmental progression 2 and end up trying to capture either the essence or the main points. Two students appeared to have followed this path – student Q and student I. The experience of student Q was briefly conveyed by an extract presented earlier (see the section 10.4.6, "*It's what I am used to*").

d) *Progression sequence 4*: This type of developmental progression is similar to the previous one in all respects except the end point. Here the student begins by listening and then switches to taking notes of some kind but despairs of the attempt or is unimpressed by the benefits and reverts to the school practice of just listening. Student AC is one example of this category. His experience was described at the end of section 10.4.6.

10.6 THE DYNAMICS OF DEVELOPMENT AND THE TIME TAKEN TO DEVELOP THE NEW PRACTICE

With regard to the manner in which the new practice developed, two different dynamics appear to have been operating: either the practice 'just evolved', or incremental step changes were adopted intentionally. In the former case, students were not able to identify any particular point in time when they intentionally changed or adapted their practice. In the latter case, students could describe the modifications to their practice which they had made intentionally although the point in time when they had made them generally eluded them.

It appears from the students' reports that the overall process of developing the new practice took time. Many students were still not satisfied with their proficiency by the time of the second set of interviews towards the end of the year. Those who were happier with their practice at that time indicated that it had taken about a semester to reach that point.

Three inter-relating factors appear to have contributed to the relatively slow development of the practice. The first factor is that it takes time to develop a difficult skill and, with regard to note-taking, many students generally found it difficult to discern main points from everything else that was said in lectures. The second factor is that many students seemed to have had an external locus of control so that they only became aware that their classroom practice was not 'working for them' when they found they were not performing well in tests. The third factor is related to the second and has to do with poor reflective practice. In the students' reports there was little evidence of effective self-monitoring of current practice and even less evidence of intentional adaptive intervention being sparked by such self-monitoring. Mostly the students' reflection, such as it was, appeared to be occasioned by crises such as poor test performance.

To conclude this section, the following rather lengthy extract is presented as something of a narrative of one student's experience in developing the balance between listening to understand and capturing the main points.

> *What you're saying is that, because of your experience of taking notes over these three quarters, you have learned to be able to distinguish what is the main point and what's not the main point.* Exactly. *How did that happen?* It takes time. [Laughs] It takes time when... like when you review your notes [after the lecture], you can actually say "ah, it was just...uh, beside you, that's the main point". *Are you saying that part of the process of learning to distinguish is the reviewing of the notes afterwards?* Yes, it is. *Can you talk a little more about this discerning the main point*. … I don't know how would I say that you develop it, but, you just develop it. *Before that you said that you spend a lot of time writing in the lecture*. A lot … At the beginning of the year it felt like everything they are saying you have to take down - you have to take down. Ya, but as time goes by you learn you understand … what to take down and what not to take down. *So are you saying you take less down now?* I still do. Ja, actually my notes is much smaller than… back at the beginning. *Was that a gradual process or was there a point at which you said, hey I'm taking too many notes, or what?* … you just develop it, sir, …you develop it, like realise like ok… coz every time you review your notes … you learn from your notes, actually say… that [particular point] was not necessary [to note down], so next time when you taking notes you exclude those stuff you think are not necessary. [J/2]

PART C: SUMMARY OF FINDINGS RELATED TO STUDENTS CHANGING THEIR LEARNING PRACTICE

This chapter has investigated the issue of how the students' learning practices changed during their first year of tertiary study. The analysis of changes in practice was based firstly on a comparison of their practices at the start and end of the year and, secondly, on the interpretation of students' stated perceptions about the dynamics that influenced whatever changes had occurred. Two contexts of change were investigated: the modification of students' existing practices; and the development of completely new practices.

With regard to how students related to receiving instructional material verbally, five categories of variation were apparent: capture everything, capture the essence, capture the main points, capture what's new, capture nothing – just listen. These categories are couched in terms of note-taking but implicit in them is the balance between the capturing of information by taking notes and listening to learn and understand.

The analysis of the extent of change in an existing learning practice (theory-focused study practice) yielded four categories of variation: no change, minor change, adapted, and shifted. The different extents of change refer to the relevant categories of practices developed in Chapter 6 and indicate whether or not the practice of a student changed qualitatively from one category of study practice to another (shifted) or changed within a category (adapted) or changed very little or not at all.

With regard to the development of the new practice of taking lecture notes, students followed one of four paths of developmental progression. These progressions began either by just-listening and writing nothing or by trying to capture everything (or almost everything) of what was said in a lecture. Thereafter, two developmental progressions led to a better balance between 'listening to learn' and 'capturing information', but the other two did not. One of the developmental progressions which did not lead to a better balance involved the student simply becoming more adept at trying to capture everything. The other progression involved the student starting off by just listening, then flirting with taking notes before deciding to revert to just-listening.

With regard to the dynamics of change that were identified in the various investigations, tentative conclusions were drawn as follows. About half of the student sample showed little or no change in their existing study practice but half of these did not really need to change very much as they had come to university with a relatively advanced level of practice. Most students who came to university with study practices that were assessed as being inadequate for effective learning at university did improve the quality of their practice but a minority (20% of the sample) appeared to have been resistant to such change. Greater resistance to change was evident among students who came to university with intermediate levels of sophistication in their study practices.

Where students did improve the quality of their study practice the extent of improvement was disappointing; in virtually all cases, it amounted to a shift only into the next most sophisticated category of practice when considerably greater extents of change were both possible and desirable. In addition, it generally took about a semester before serious efforts were made to change. It appeared that most students needed to become sensitized to the need to change before they became receptive to input on how to improve their study practice. Of those students who changed their practice, only about a third responded to such input when it was given at the beginning of the year. For the rest, it took poor performance in the mid-year exams to become receptive to acting on relevant input. Before then, the implications of poor performance in assessments appeared to have been disregarded on the basis of reasoning such as 'I am still adjusting' or 'I can still catch up'; it appeared that a 'school mentality' still prevailed and the recognition that there were problems with their existing study practices was slow in coming.

Part of the reason for the slowness of this recognition appears to derive from the nature of their reflective practice and/or from the nature of their locus of control. Many students appeared to rely on

their performance in tests or on their ability to solve problems for indications about the quality of their understanding. There was little evidence among the students of the kind of reflective practice that involving an on-going monitoring of and, where appropriate, intervention with the current status of their practice. Mostly their reflection, such as it was, appeared to be occasioned by crises such as poor test performance.

The findings from the investigation into the development of note-taking practice provide a valuable window on change because they relate to the development of a new practice. All students of necessity began to develop this practice from the outset and did not need to become sensitized to the need to do so in the same way as was necessary with regard to modifying their existing study practices. Nevertheless, the process of developing the new practice was slow and, even in the third academic quarter, many students reported still not being comfortable with the level of their proficiency. It appeared that the difficult skills associated with discerning the main points in a lecture and in writing while listening took time to develop even with the extensive practice of doing it for several hours every day over a semester! This observation has implications with regard to the understanding of the developmental dynamics associated with the modification of existing practices where, not only must aspects of existing practices be changed, but new practices need to be developed and refined also, and all this needs to happen in a learning context that students generally experience as being pressured, stressful and demanding.

CHAPTER 11: DISCUSSION: THE STUDY FINDINGS AND THEIR IMPLICATIONS

The previous five chapters presented the various findings of the analyses of the study data. This chapter focuses on what those findings mean, and how they address the objective of the study and the research questions posed. It begins by drawing the findings of the study together. This is done in Part A which summarizes and discusses the conceptual framework that has been developed on learning practices, the overall outcome space of the phenomenographic investigation, and a synthesis of insights about the dynamics associated with how students' learning practices change. Part B discusses some general outcomes of the study while Part C looks at the implications of the study findings and what they indicate about our students and the kind of interventions that could be implemented to improve their academic prospects by facilitating an improvement in their learning practices.

PART A: A SYNTHESIS OF THE FINDINGS FROM THE STUDY

The unit of analysis in this thesis is 'learning practices'. Therefore, the first issue that was tackled in the literature survey in Chapter 2 was the meaning of the term and how it would be used in the study. It was evident from that survey that the term has not been used previously in a technical sense in the context of student learning. Accordingly, a formal conceptual framework for the construct was developed in Chapter 3. That framework is foundational to the study and is also a significant outcome of the study; it is the first outcome of this thesis. Consequently, the discussion of the outcomes of the study begins with a summary of that conceptual framework and then focuses on the findings in regard to the three research questions that have been addressed.

11.1 A CONCEPTUAL FRAMEWORK FOR LEARNING PRACTICES

In Chapter 3, the development of a formal conceptual framework for the nature of learning practices drew from various sources including cognitive psychology, philosophy, semiotics, the literature on approaches to learning, and, to a limited extent, neuroscience. The conceptual framework that was developed provided a detailed definition of 'learning practices' (section 3.10) as well as a practice-based perspective of the nature of student learning (Part B of Chapter 3). That perspective and the definition can be summarized as follows.

A person's learning practice (singular) consists of a repertoire of practices each of which is an *orientation* to act in learning situations in a certain way and with a certain intention. These orientations are largely intuitive in nature and have been developed and to some degree automatized as a result of past experience. Each one of a person's learning practices is underpinned by a web of conceptions that are tightly associated with a body of tacit knowledge and intuitive and explicit processing capabilities. These include interpretive and responsive capabilities that orientate the person to interpret learning situations in particular ways and to respond to them accordingly. The automatized nature of these

processes means that familiar studying and learning activities in familiar contexts tend to be executed intuitively – reactively rather than proactively – and with a high degree of proficiency at whatever level of sophistication the student has developed in their practice. More negatively, it means that a student is orientated to study and learn in particular ways irrespective of how appropriate or effective those ways may be in a particular learning context and it takes deliberate effort to act in some other way. Only if the learning context prompts them to think more proactively about the demands of the context are they likely to act in some other way. In addition, it means that, in order to modify an established practice with a new practice, a student must develop sufficient experience with the new practice so that it becomes more or less as well automatized as the old practice otherwise the student is likely to revert to the old practice when under pressure.

With regard to how students engage in studying and learning activities in the moment and how learning practices are involved in such engagements, the conceptual framework of learning practices is in line with the 3P model of student learning described in the SAL literature and reviewed in Chapter 2. It holds that specific learning activity in the moment is driven by the way in which a person interprets the learning situation in the moment and what these interpretations mean for that student – what they perceive the moment affords them or demands of them. The nature of these interpretations is shaped partly by the nature of the learning situation and partly by the student's interpretive practices which they have developed from prior experience and constitute a part of their overall learning practice. The intersection of these interpretations with the general values, goals and dispositions of the student – their 'dispositional attributes' – evoke an intention to act in the moment in a certain way and the intention then leads to and guides action based on the repertoire of possible ways of acting that the student currently has at their disposal in their repertoire of practices. Such activity changes the situation in which the activity is taking place which then leads to regulation activities that involve further iterative cycles of perception, intention and consequential action. The interpretive and responsive processes which have been described are largely the result of intuitive, automatized processing and so are executed with little conscious attention at whatever level of proficiency the student has developed; i.e. the way students engage in the moment – the approach to learning which they adopt – is an evoked response dependent on how they perceive the learning situation which they encounter.

11.2 THE OUTCOME SPACE OF THE PHENOMENOGRAPHIC STUDY: THE VARIATION IN THE STUDENTS' LEARNING PRACTICES

Research questions (a) and (b) called for an investigation into the variation in the learning practices of the students. In response, six types of learning practices were investigated using the phenomenographic methodology described in Chapter 4. The outcome spaces that emerged from these investigations are summarized in Figure 11.1 and are discussed thereafter. (To make reference to the figure easier while reading the discussion, the reader may like to fold out the copy of the figure in Appendix B, p 188.)

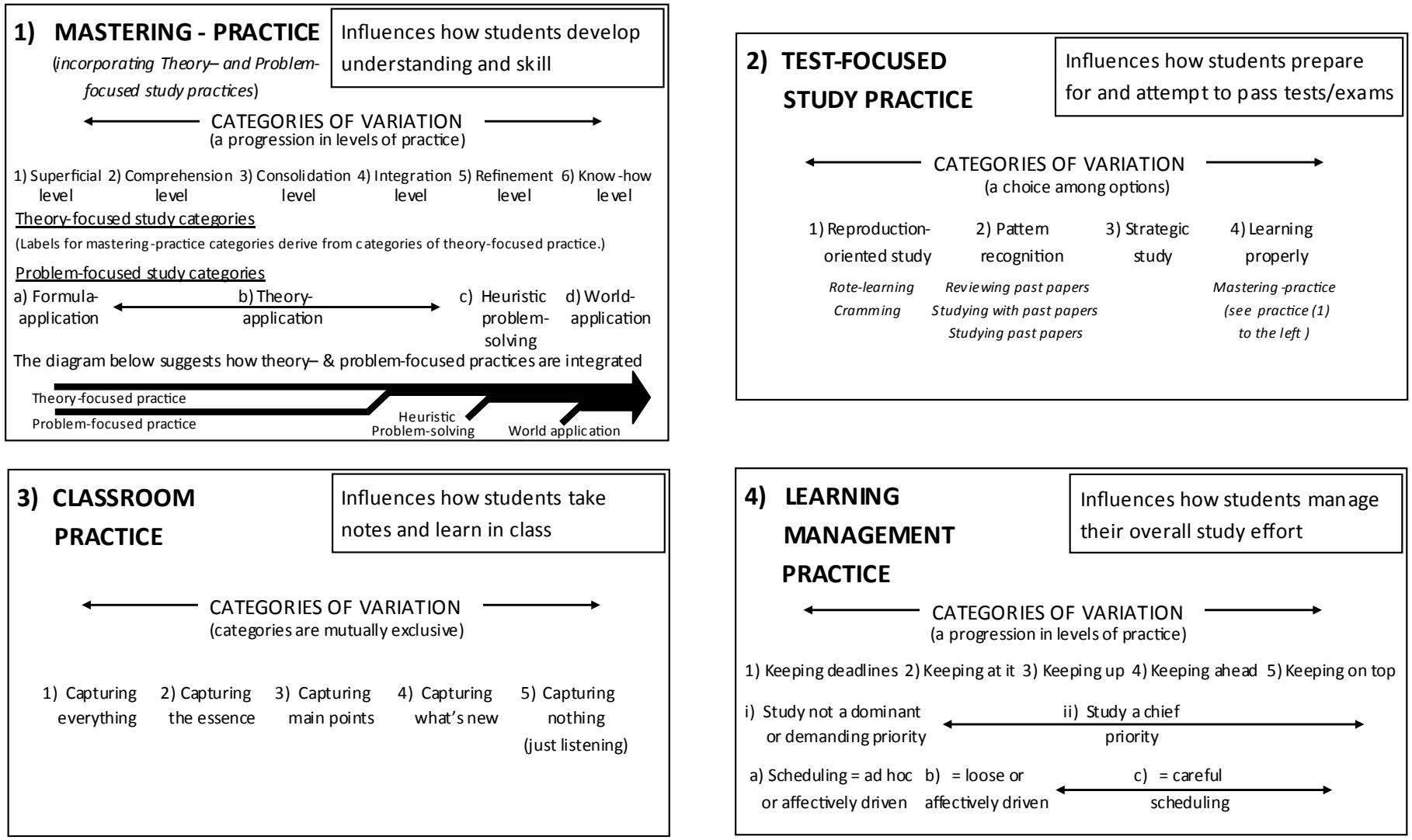


Figure 11.1: The Overall Outcome Space from the Phenomenographic Study: The Categories of Variation of Different Types of Learning Practices

As Figure 11.1 indicates, 3 of the 6 types of learning practices investigated (mastering-practice, and theory- and problem-focused study practices) relate to the context of studying when alone and when the intention is the mastering of course material; i.e. the focus is to learn in order to understand as opposed to learning in order to pass impending tests/exams. The other types of learning practices investigated (test-focused study practice, classroom practice, and learning management practice) relate respectively to the contexts of preparing for tests/exams; engaging with formal verbal input in the classroom; and organizing and managing one's overall study effort in the overall context of student life. A brief summary of each of these types of learning practices follows after which the structure of the outcome spaces considered together is discussed.

Mastering-practice is a meta-practice consisting of theory-focused study practice and problem-focused study practice integrated together. As discussed in Chapter 8, the qualitative variation in mastering-practice can be described in terms of 6 categories which form a progression in degree of sophistication from a superficial level, to a comprehension, a consolidation, an integration, a refinement, and a know-how level of mastering-practice. Each level involves one category of theory-focused study practice (see Table 6.2, page 75) and one category of problem-focused study practice (see Table 7.1, page 90). Levels of mastering-practice which are less sophisticated than the integration level of practice exercise theory- and problem-focused study practice relatively independently of each other. More sophisticated levels of mastering-practice include the ability to exercise theory- and problem-focused study practice together in a more integrated manner as a result of the explicit awareness that engagement with theory develops the basis for solving problems and the solving of problems enhances the understanding of theory. In addition, each category of mastering-practice presupposes the less sophisticated categories.

The progression in the sophistication of the categories of mastering-practice is associated with an increase in the level of understanding and skill. Accordingly, except for the most sophisticated category, there is inherent in each category of mastering-practice a constraint on learning because it does not explicitly afford the development of the levels of understanding and skill afforded by more sophisticated levels of practice. In addition, variation in the quality of students' learning outcomes is to be expected simply because of the variation in students' mastering-practices. This is irrespective of whether or not students are learning for reproduction. Put another way, there is variation in students' orientations to learning that is irrespective of the deep-surface (meaning-reproduction) distinction which the SAL tradition highlights.

Test-focused study practice. As discussed in Chapter 9, the variation in test-focused study practice can be described in terms of 4 categories. One of these is to 'learn normally', i.e. to exercise one's mastering-practice as one normally does when tests/exams are not pending. The other three categories – reproduction-oriented study, pattern recognition and strategic study practices – involve, to a greater or lesser extent, an orientation to learn *information* with the intention of reproducing it in tests/exams – i.e. to use rote-learning, memorizing, or cramming practices. As discussed in Chapters 6 and 9, these

practices are equivalent to the least sophisticated of the categories of mastering-practice – i.e. information-oriented study practice; the strategies used are similar but the intention is different. However, more sophisticated learning practices may also be used when engaging with past test/exam papers (pattern-recognition practice) or when adjusting one's study practice according to perceptions about how topics will be assessed (strategic study). These practices do not necessarily preclude the exercise of some kind of mastering-practice in addition to simply learning information. As such, test-focused study practices influence the quality of learning outcomes by the degree to which they divert a student from exercising the mastering-practice of which they are capable. Further, it is evident from this discussion that the distinction between mastering-practice and test-focused study practice corresponds to the distinction between deep and surface orientations to learning respectively.

Classroom practice. A student's classroom practice consists of orientations that influence how they take notes and how they listen in order to learn when receiving formal instruction. As discussed in Part B of Chapter 10, these two aspects of practice are in tension in that attention given to taking notes detracts to some extent from attention given to trying to understand what is being said. Accordingly, the variation in classroom practice can be described in terms of either note-taking or listening-to-learn. As Figure 11.1 indicates, the variation has been described in terms of five categories of note-taking practice: i.e. capturing everything, the essence, the main points, what's new, and capturing nothing – just listening.

These categories, as listed, form two progressions – a decrease in the extent of note-taking combined with an increase in the attention given to listening in order to understand what is being said. The first and last of these categories – capturing everything and just listening – are the least sophisticated categories of classroom practice because they pay little attention to one or other of the aspects of that practice. The more sophisticated categories of practice – 'capturing the essence' or 'capturing the main points' – are the ones which attempt to achieve an effective balance between the two aspects of the practice.

While note-taking and listening-to-understand constitute only initial stages in student learning, it is obvious that both can affect the quality of learning outcomes achieved. Notes taken in class constitute an important learning resource for subsequent study and so affect the quality of that study. In addition, the quality of listening affects the quality of the initial understandings that are gained during class.

Learning management practice. A student's learning management practice has to do with how they relate to and manage their overall study effort which in turn influences how each of the other types of learning practices is exercised. This study has found that there were two general aspects to the way in which students related to the management of their study effort. One was dispositional in nature and influenced their study prioritization. The other had to do with how they related to scheduling.

The variation in students' study prioritization can be described in terms of four categories (see section 9.3). In summary, the combined effect of dispositional attributes (such as motivation, interest in the subject, work ethic, attributions, and self-discipline) can result in a student prioritizing study as their *chief priority*. Alternatively, a student might view what needs to be learned as being sufficiently easy and non-demanding in nature that it can be 'fitted in' without having to sacrifice other interests or indulgences. Here study is *a non-demanding priority*. A more extreme version of this is where other priorities take precedence and study is *not a dominant priority* at all. Finally, if interest in the subject begins to fade for whatever reason, study may become *a declining priority*.

With regard to students' scheduling practices (how they were oriented to scheduling their time, their study, and their work effort), four categories of variation were identified: scheduling that was *ad hoc, loose, affectively-driven,* or *careful* in nature (see section 9.4). These categories, as listed, constitute a progression from disordered to ordered scheduling, and from being relatively undisciplined to being disciplined when planning and sticking to schedules.

The study found that the variation in students learning management practice, as influenced by their study prioritization and scheduling practices, could be described in terms of five categories which constituted a progression from *keeping deadlines, keeping at it, keeping up, keeping ahead,* to *keeping on top.* Keeping deadlines is a *basic learning management practice* which typically involves little more than being regulated by the schedule of tutorials, practicals, tests and examinations imposed by the teaching and learning context with its set timetables and hand-in deadlines. Typically, study is viewed as being other than the chief priority and/or scheduling practice is ad-hoc or affectively-driven in nature. The category of 'keeping at it' is characterized by the rather unsophisticated view that 'working hard' is the dominant imperative when managing one's overall study effort, hence the category was labelled '*the work-hard learning management practice'*. The remaining three categories – keeping up, ahead, and on top – constitute a progression from *being diligent* in keeping abreast of course material as it unfolds and not leaving study to the last minute before a test/exam; to *being anticipatory* in trying to read ahead of lectures; and to organizing one's study with the intention of mastering course material incrementally so that one stays *on top* of one's work.

As was the case with classroom practice, learning management practice influences the quality of students' learning outcomes through its influence on the other learning practices that have been described. The nature of these influences and of the inter-relations between the different types of learning practices that have been described is one of the issues discussed in the next section.

11.3 THE STRUCTURE OF THE OVERALL OUTCOME SPACE

In an educational context, the outcome space from a phenomenographic study has pedagogical power to the extent that it is able to usefully inform teaching and to guide the design of teaching and learning environments, interventions or curricula. This power derives from the way that the categories of

variation imply what would need to happen for a student to develop their practice from one category to another. The features that distinguish one category from another and the general structure of the outcome space give insight into what it is that must be addressed to foster changes of this kind.

With regard to the present study, the basic structure and content of the overall outcome space has been set out in the previous section. However, three important structural features of the outcome space have not been highlighted in the discussion so far and so require attention. These have to do with the features which characterize the variation in each type of learning practice; the inter-relation between the different types of learning practices; and the affordances and constraints that affect the quality of student learning.

11.3.1 Distinguishing features which characterize the variation in learning practices

From a review of the categories of variation associated with each type of learning practice that has been investigated, it is evident that the intentions and strategies/ways-of-acting which characterize each category of practice each have one or more of five kinds of distinguishing features: i.e. conceptions, dispositions, learning tools, strategies, and resources. For example, the variation in theory-focused study practices is characterized by a variation in conceptions about the type of knowledge to be learned and a variation in conceptions about how to develop that type of knowledge. It is also characterized by a variation in the strategies, resources and learning tools which students use to develop that knowledge.

Table 11.1 presents a list of distinguishing features of this kind that have been identified in the study. Pedagogically, this list is very useful because it identifies the features which should be given attention when thinking about how to foster change from one category of learning practice to another. It is also potentially useful for identifying associations between different types of learning practices. This point requires further explanation.

It is evident from Table 11.1 that several types of learning practices have one or more distinguishing features in common. For example, the conception of the nature of knowledge is one of the features distinguishing the variation in three of the four types of learning practice indicated there – mastering-practice, learning management and test-focused study practice. This implies that the categories of these aspects of a student's learning practice will be those that have the same conception of knowledge in common. This observation suggests that there should be patterns of association between different types of learning practices that derive from having the same distinguishing feature in common. Although this point is not strongly supported by the study data, it can be argued from the conceptual framework described in section 11.1; i.e. while a student's practices in different contexts may be different in nature they are not mutually independent because they all draw from the same pool of conceptions, dispositions and other distinguishing features which the student has built up from prior experience.

Table 11.1: Distinguishing Features which Characterize the Variation in Learning Practices

Type of Learning Practice	Conceptions and Other Features that Characterize the Variation in the Practice
THEORY-FOCUSED STUDY PRACTICE (An aspect of Mastering-Practice)	Conceptions about … ● type of knowledge to be learned ● how to learn it Other Features … ● resources/learning tools ● type of study strategy
PROBLEM-FOCUSED STUDY PRACTICE (An aspect of Mastering-Practice)	Conceptions about … ● the nature of problems ● type of problem-solving skill to be developed ● how to develop that skill Other Features … ● type of problem-solving strategy
THEORY- and PROBLEM-FOCUSED PRACTICE TOGETHER	Conceptions about … ● how theory and problems inter-relate
TEST-FOCUSED STUDY PRACTICE	Conceptions about … ● the objective of studying ● what earns marks in tests ● the nature of knowledge ● the nature of mastering-practice Other Features … ● type of test-preparation strategy ● past test/exam papers/questions
CLASSROOM PRACTICE	Conceptions about the importance of … ● note taking ● understanding what is said in lectures Other Features … ● type of note-taking strategy
LEARNING MANAGEMENT PRACTICE	Conceptions of … ● the kind of space/time needed for study ● the nature of knowledge ● the nature of learning ● the objective of tests/exams ● the nature of mastering-practice ● the nature of test-focused study practice ● reasons for studying Other Features … ● scheduling orientation ● study prioritization ● dispositions related to study prioritization

11.3.2 The inter-relations between the different types of learning practice

While there are various kinds of inter-relations between the different types of learning practices, such as the associations just described between categories that share common distinguishing features, the kinds of inter-relations that are most significant pedagogically are obviously those which affect the quality of student learning. In this regard, the inter-relations between theory and problem-focused study practice, and also between mastering-practice and test-focused study practice are obviously highly relevant and have already been discussed in some detail. Other inter-relations that potentially affect the quality of student learning can be inferred by considering the essential nature of the different types of learning practices. These are summarized in Figure 11.2. (Note that the figure includes help-seeking and study group practices although these have not been investigated or discussed in detail in this study.)

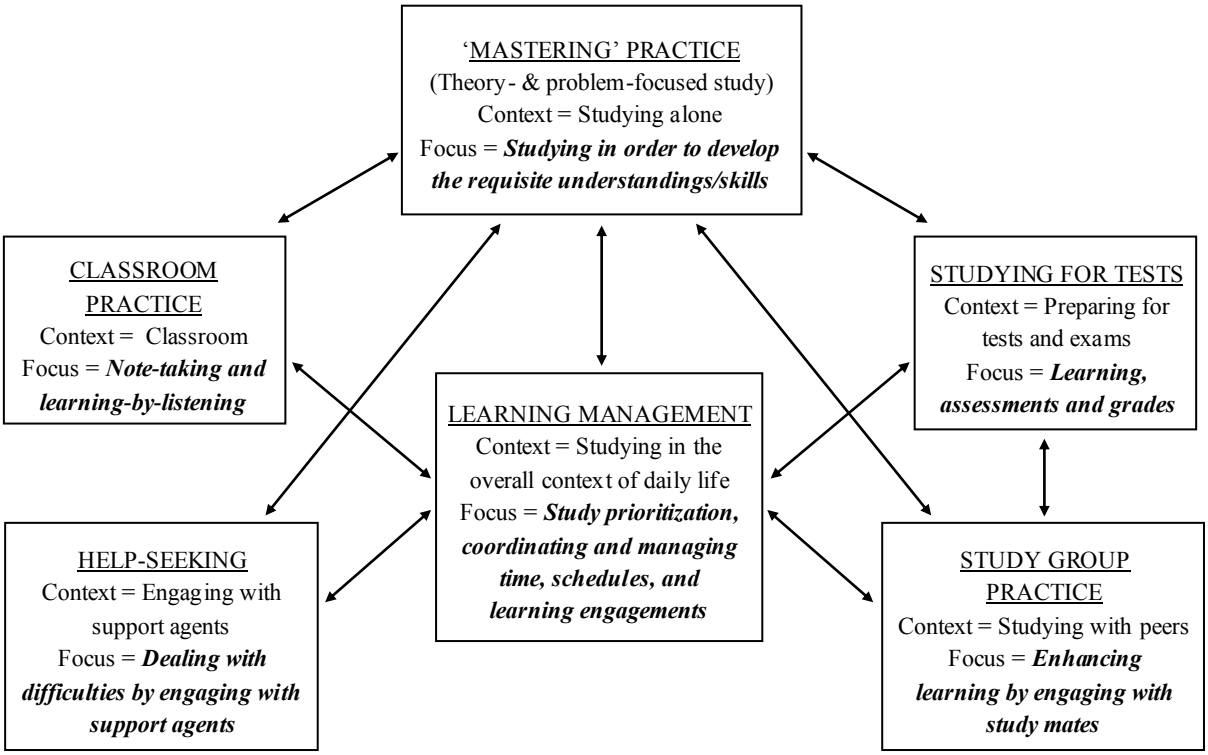


Figure 11.2: Inter-Relations between Different Types of Learning Practices
(Presented previously as Figure 5.1)

The figure indicates the context and focus of each of the types of learning practices that have been mentioned in the thesis up to this point. The arrows in the figure give a general indication of the inter-relations between the various types of practice. Mastering-practice is focused exclusively on developing the requisite knowledge, understandings and skill and each of the other practices assist in this endeavour in various ways. Classroom practice contributes to the development of understanding/skill by providing resources (notes taken in class) and the initial understandings gained in class. Help-seeking practice contributes by attempting to resolve difficulties that might crop up. Study-group practice contributes by seeking to enhance or accelerate the development of understanding/skill by means of collaborative learning of some kind. However, it seems reasonable to argue that the lines of influence also go in the reverse direction; that the nature of a student's mastering-practice will influence how they typically go about learning in class, in groups and when seeking help. For example, if a student typically exercises a refinement level of mastering-practice, the way they listen in class and interact with others is likely to be characterized by a disposition to make conceptual connections and understand as deeply as possible.

It is obvious that, with regard to learning management practice, the way a student goes about organizing and managing their study effort will have a profound influence on the exercise of each of the other practices. Again, the influence is mutual in that the way a student generally exercises each of the other practices would be expected to influence how that student organizes and manages their study effort.

While most of the inter-relations that have been described in this subsection do not explicitly derive from the study data but are the result of reasoning, they appear to be intuitively and sufficiently obvious to be accepted as being reasonable.

11.3.3 Constraints and affordances

The pedagogical implications of the outcome space as a whole and of its structure, inter-relations and distinguishing features are brought into sharper focus by thinking in terms of affordances and constraints and the idea that learning practices both afford and constrain the development of particular levels of understanding and skill. These ideas were first introduced in this thesis in Chapter 6 (section 6.2) and were also mentioned earlier in this chapter (section 11.2). There it was reiterated that a particular category of learning practice constrains learning because it does not explicitly afford the development of understandings/skills that are afforded by more sophisticated categories of practice. Thinking in terms of constraints and affordances in this way accentuates the link between the quality of learning practice and the quality of learning afforded by the exercise of that practice and thereby highlights the pedagogical significance of whatever aspect of practice is being considered. A further advantage of thinking in these terms is that it leads to useful insights about how to facilitate improvements in student learning without having to take into account the network of other factors that influence the quality of that learning.

Much attention was given in Chapters 6 to 8 to the ways in which different aspects of mastering-practice inherently constrain learning and the way in which the boundaries between most of the categories of mastering-practice (and between some of the subcategories) constitute 'thresholds' into levels of practice that inherently afford the development of deeper levels of knowledge, understanding and skill. The structure of these 'constraint thresholds' (i.e. where they are located in the outcome space) has been described in Chapters 6 to 8 and has been presented in Tables 6.2 and 7.1 and in Figure 8.1. However, these constraint thresholds are not the only ones that can be identified. In principle, any category or aspect of learning practice influences the quality of a student's learning in some way and so can be examined from the perspective of constraints and affordances.

One aspect of the outcome space where the perspective of constraints provides valuable clarification is with regard to the inter-relations between different types of learning practices. As discussed in the previous subsection, the nature of these inter-relations was explored primarily by reasoning and inference because the analysis of the study data was only able to provide a partial indication. To conclude this part of the chapter, therefore, those inter-relations are re-considered from the perspective of how they enhance or constrain the quality of student learning.

The general conclusion that emerges from asking how these inter-relations influence the quality of a student's learning is to note that it is a student's mastering-practice that is the primary factor in determining the quality of the knowledge, understanding and skill achieved, and that other aspects of a

student's learning practice enhance or constrain student learning by the extent to which they affect the quality of a student's mastering-practice. So for example, a student's mastering-practice (and hence the quality of their learning) can be enhanced by learning management practices that prioritize study, and schedule and manage the student's study effort effectively. In contrast, the quality of student learning will be constrained if the quality of any of these aspects of learning management is poor. Similarly, classroom, help-seeking, and study-group practices will enhance the quality of mastering-practice if they typically provide quality lecture notes and good initial understandings from class, if they typically help to resolve conceptual difficulties, or enhance conceptual understandings through collaborative engagement with peers. However, these practices will constrain the quality of learning to the extent that they fail to contribute to mastering-practice in the ways described or actually inhibit or divert attention away from mastering-practice as, for example, most categories of test-focused study practice tend to do.

11.4 A SYNTHESIS OF INSIGHTS ON THE DYNAMICS AFFECTING HOW THE LEARNING PRACTICES OF OUR STUDENTS CHANGE

Research question (c) called for an investigation into the perceptions the students had about how their learning practices had changed during their first year at university. The findings from that investigation are idiosyncratic to the students in the study and the cohort which they represent. The findings were reported in Chapter 10 and are presented here as a synthesis of insights about the dynamics of change of the learning practices of our students.

Insight 1: The provision of measures intended to change students' learning practices must take into consideration that there are two quite different contexts of change: developing new practices; and modifying existing practices. Unlike with the modification of existing practices, the process of developing a new practice is unencumbered by having to deal with the influence of alternative practices that are more well-established. This means that interventions in the two contexts, though they may have features in common, should be different in ways that will become evident as the presentation of these insights unfolds.

Insight 2: Pedagogical implications with regard to developing new learning practices. Of the practices investigated, the practice of note-taking in lectures is the most prominent instance of the students having to develop a practice that is completely new to them. The findings in regard to the ways in which their practice develops are detailed in Part B of Chapter 10. With respect to pedagogical implications, the following specific points are relevant. Even with the extensive practice of having to take notes on a daily basis, it takes up to a semester for the majority of the students to reach a level of proficiency with which they are reasonably satisfied. Students appear to develop their practice in one of three qualitatively different ways: the new practice just 'evolves'; students modify their practice at specific points in time when they realize that there is 'something wrong' with what they are doing or

that their practice 'isn't working for them'; and students reflect on the quality of their notes when they review them and modify their note-taking practice accordingly.

Insight 3: Pedagogical implications with regard to the modification of existing learning practices. Although students reported changing many aspects of their learning practice, the insights reported here have been gleaned from an analysis that concentrated on changes in their theory-focused study practices. The relevant findings are detailed in Part A of Chapter 10. The most significant pedagogical implications emanating from these findings are as follows.

3a) When and why students change their practice. Most students need to become sensitized to the need to change before they become receptive to input on how to improve their study practice. Few students shift their study practice as a result of class or textual input on the subject. Most students who recognize that they need to be serious about changing their study practice seem to take about half the academic year to reach this 'wake-up' conclusion. The primary factor in students hearing this 'wake-up call' appear to be the stress created by getting poor grades and the student's realization that their current study practice was not 'working for them' in the sense that it did not facilitate the achievement of satisfactory grades. Poor performance in the first semester appears to be far less of a change driver than poor mid-year marks. Before mid-year, the implications of poor performance appear to be disregarded on the basis of reasoning such as 'I am still adjusting' or 'I can still catch up'.

3b) Dealing with student diversity. About half of the students show little or no change in their study practice during their first year at university. About half of these are students who come to university with relatively advanced learning practices and, not surprisingly, have little need to change their practice. Of the students whose learning practice on entry is inadequate for effective learning at university, some appear to be resistant to changing their practice. The remainder do appear to improve the quality of their practice but the extent of that improvement is disappointing. A greater resistance to change is evident among students who come to university with intermediate levels of sophistication in their study practices.

The pedagogical implications of these observations are that different kinds of interventions are required for students who enter with different degrees of sophistication in their learning practices. Interventions for students with unsophisticated learning practices should concentrate on achieving a larger degree of improvement than seems to occur normally. Students with intermediate levels of sophistication appear to require particular attention in regard to sensitizing them to the importance of improving their practice. Students who need to improve their practice but appear to be resistant to this require a different kind of intervention as discussed next.

3c) The issue of resistance to change. Pedagogically, the problem with students who seem resistant to change appears to be a combination of a lack of a reflective disposition; an external locus of control which makes it difficult for the student to recognize that it is the quality of their practice that needs to

be improved; possibly a lack of awareness about other options; and possibly other factors of a personal or circumstantial nature. From the study's conceptual framework, it would appear that resistance to changing one's learning practice is more implicit than explicit in nature and is inherent in the automatized character of practices in general – in other words, students may simply continue doing what they have been accustomed to doing in the past.

The pedagogical implications of these observations are that, in order to combat apparent resistance to change, students need to be made aware that more effective options are available to them and can be developed with time and application and that intentional and sustained application is needed for new practices to become automatized. In addition, interventions should make the development of reflective practice a high priority. Further, the teaching and learning environments should be conducive to the modification of learning practices. In this regard, aspects that are antithetical to such development include a pressured environment (which fosters reversion to learning practices that proved effective in the past); reliance on instruction as opposed to immersion (practices are developed by automatization processes not by a transfer of 'head knowledge'); and reliance on a stand-alone course for developing students' learning practices (other courses may reinforce existing practice or may undermine the developmental efforts of the stand-alone course).

PART B: GENERAL PEDAGOGICAL OUTCOMES OF THE STUDY

Part A of the chapter summarized and discussed the outcomes of the study that related directly to the research questions. However, three additional outcomes of pedagogical interest were forthcoming from the study: a model of the structure of understanding and skill; a descriptive model for profiling the learning practices of students; and a strategy for improving student learning. These outcomes constitute tools that can be used in efforts to improve the learning of students by facilitating improvements in the quality of their learning practices.

11.5 A PRACTICE-BASED MODEL OF THE STRUCTURE OF UNDERSTANDING AND SKILL

One of the outcomes of this study is a model of the structure of knowledge, understanding and skill. The model is derived from the structure of the variation in mastering-practice and functions as a framework for assessing the quality of learning of engineering students. In effect, it is the structure of the outcome space of the variation in mastering-practice viewed from the perspective of the variation in the quality of student learning rather than the variation in their learning practice. The nature and formulation of the model are described as follows.

The different categories of mastering-practice that have been identified in this study (see section 8.3) are characterized by particular types of knowledge and problem-solving skills. The progression from the least to the most sophisticated of these categories corresponds to a progression corresponding to an

increase in the complexity and 'depth' of knowledge, understanding and skill and the degree to which they are comprehended, consolidated, integrated, refined and related to real world situations. This progression constitutes a spectrum that covers a range from a very superficial level of understanding and skill to the expertise and know-how of an expert. As such this spectrum constitutes a credible model of the structure of understanding and skill applicable to the domain of engineering. The structure is set out in Table 11.2. The table includes the categories of mastering-practice from which the elements of the structure derive so that the link between the structure of understanding and skill and learning practices is maintained.

Table 11.2: A Practice Perspective on the Structure of Understanding and Skill and Its Link to Mastering-Practice

(Previously presented as Table 8.2.)

	THE STRUCTURE OF UNDERSTANDING AND SKILL		
Level of Mastering-Practice	**Type of Knowledge**	**Type of Problem-Solving Skills**	**Degree of Integration**
Superficial	Information	Formula-application skill	Un-integrated conceptions of theory and problems.
Comprehension	The above plus comprehended theory	The above plus theory-application skill	
Consolidation	The above plus consolidated theory	As above	
Integration	As above	As above	Integrated conceptions of theory and problems.
Refinement	The above plus personally refined theory	The above plus heuristic problem-solving skill	Integrated conceptions of theory, problems and heuristic problem-solving.
Know-How	The above related to real world situations	The above plus world-application skill	Integrated conceptions of theory, problems, and heuristic problem-solving, as being relating to real world situations.

If 'quality of learning' is taken to mean *the depth of knowledge, understanding and skill that is developed when a student learns*, then the structure of understanding and skill set out in the table constitutes a credible basis for describing quality of learning. According to this basis, high quality learning would lead to the achievement of the more complex and sophisticated structures of understanding and skill while low quality learning would lead to the achievement of only the least sophisticated structures. The utility of the model is that it provides a tangible link between learning practices and the quality of learning which those practices afford.

11.6 A DESCRIPTIVE MODEL FOR CHARACTERIZING THE LEARNING PRACTICE (SINGULAR) OF INDIVIDUAL STUDENTS

The outcome space that has been summarized and discussed in Part A relates to students as a collective not as individuals. In principle, any individual might very well exercise one or more – or even all – of

the categories of practice in each of the learning contexts covered by the outcome space. Consequently, when contemplating pedagogical measures intended to help students in a cohort to improve their learning practices, some additional profiling information is needed to give an indication of what aspects of learning practice require attention. Such information can only be acquired by characterizing the learning practices of individuals in some way using a survey instrument of some kind such as an inventory. Whatever instrument is used, it requires a descriptive model of the learning practices of students that provides a framework for the characterization. This section develops such a descriptive model based on the categories that define the outcome space described earlier.

Because learning practices are *orientations* to act in certain ways they are trait-like in nature and students cannot be oriented to engage in a certain way if they have had no prior experience of doing so. Consequently, when the categories of practice in a particular type of learning practice constitute a progression in level of sophistication, it is possible to characterize the practice of an individual in terms of the most sophisticated level of practice which they have developed. When this is done the less sophisticated categories of practice are presupposed. As discussed in Chapters 6 to 8, it was possible to characterize theory- and problem-focused study practices, and mastering-practice in this way. A similar approach was adopted for characterizing a student's learning management practice (see Part B of Chapter 9).

Classroom practice and test-focused study practice cannot be characterized in the manner just described even though progressions in degree of sophistication are evident in the variation in both types of practice. In the case of classroom practice (see Chapter 10), the reason is that the practice involves both note-taking and listening-to-learn and the progressions associated with the two are in tension. Accordingly, a student's classroom practice is characterized by the particular balance they strike between note-taking and listening-to-learn. Each category of practice is therefore mutually exclusive and a student's practice is characterized simply by stating which category of practice they are oriented to exercise.

With regard to test-focused study practice (see Part A, Chapter 9), the four categories of practice (reproduction-oriented study, pattern-recognition, strategic study and studying normally) are associated with progressions with respect to conceptions about what it takes to earn marks in tests/exams; with respect to sophistication in the approach to preparing for tests/exams; and with respect to the degree to which the practice diverts attention away from learning-for-understanding. In addition, the variation in practice is associated with differences in the resources used when preparing for tests/exams: i.e. course material; past papers; and conceptions about the nature of the assessment procedures used. One consequence of these features of test-preparation practice is that its categories of practice are not mutually exclusive nor does one necessarily presuppose another. Accordingly, a student may exercise any mix of the categories of practice perhaps even during the same study session. To characterize a

student's test-preparation practice, therefore, involves simply indicating which category of practice or mix of practices they typically employ.

In summary, the descriptive framework (model) for characterizing a student's learning practice (singular) consists of the categories of practice set out in Table 11.3. A student's learning practice is then characterized by just one category of practice in each context of learning except for their test-focused study practice where specifying more than one category may be necessary. The table includes help-seeking and study-group practices but only in a very rudimentary form because these aspects of learning practice were not investigated in detail in the study. The table also highlights which category or categories in each type of learning practice are the more sophisticated.

Table 11.3: A Descriptive Model for Characterizing a Student's Learning Practice

TYPE OF LEARNING PRACTICE	CATEGORIES OF PRACTICE (The most sophisticated categories are the ones that have been ringed)
Mastering-Practice	1) Superficial Level; 2) Comprehension Level; 3) Consolidation Level; 4) Integration Level; 5) Refinement Level; **[6) Know-How Level]**
Learning Management Practice	1) Basic Level *(Keeping Deadlines)*; 2) Work-Hard Level *(Keeping At It)*; 3) Diligent Level *(Keeping Up)*; 4) Anticipatory Level *(Keeping Ahead)*; **[5) Comprehensive Level *(Keeping On Top)*]**
Test-focused study practice	1) Reproduction--oriented study *(Rote Learning) (Cramming)*; 2) Pattern-recognition practice *(Studying past papers)*; 3) Strategic study; **[4) Studying with past papers *(Studies & reviews work & past papers)*; 5) Studying normally *(Pays little attention to past papers)*]**
Note-taking Practice	1) Capturing everything; **[2) Capturing the essence; 3) Capturing main points]**; 4) Capturing what's new; 5) Capturing nothing – just listening
(Study-group Practice*)	**[1) Studies in groups and also alone]**; 2) Only studies alone
(Help-Seeking Practice*)	**[1) Seeks help when needed]**; 2) Doesn't seek help

* As intimated in Chapter 5, further research is required to identify more meaningful categories for these two types of learning practice.

11.7 A PRACTICE-BASED STRATEGY FOR IMPROVING STUDENT LEARNING

The intention behind this study was to gain evidence-based insights about the learning practices of our students so that such knowledge could inform efforts to improve student learning by facilitating improvements in their learning practices. This section responds to that intention. It synthesizes the insights that have been gained into a pedagogical strategy for improving student learning. The strategy consists of 10 points some of which are premises and some specific strategies. Each point is now presented (in italics) followed by a comment or explanation as is appropriate.

Point 1: The quality of a student's learning practice is defined in terms of the quality of learning which it affords. This point is taken as self-evident.

Point 2: While the quality of learning is defined in general as 'the depth of knowledge, understanding and skill that is developed when a student learns', the quality of learning in the domain of engineering education can be defined more specifically in terms of the 'structure of understanding and skill' presented in Table 11.2. Section 11.5 explains and justifies this structure and its utility for linking learning practices and the quality of learning which they inherently afford.

Point 3: The quality of a student's learning is determined by the quality of their learning engagements in the moment. Although this point is somewhat self-evident, a detailed perspective on the nature of learning engagements and the role of learning practices in them is provided by the practice-based conceptual framework of student learning described in section 11.1. In essence, it posits that various factors influence the way a student engages in studying and learning activities, one of which is the set of intuitive interpretations and responses that emanate from their learning practice. Another is the nature of the learning context and the learning situation, a point that needs to be taken into account when designing interventions intended to help students to modify their learning practices.

Point 4: Because of the multiple influences on the quality of learning, an effective way to assess the influence of particular factors is to focus on the extent to which each constrains learning. The focus on constraints is helpful because it avoids the need to identify all factors that influence learning and also bypasses the difficult question of assessing the relative impact of each influence. This leads directly to the next point.

Point 5: One way of identifying how the quality of a student's learning might be improved is to focus on the constraints inherent in their current learning practice and on ways of overcoming those constraints. This point is argued in detail in section 11.3.3.

Point 6: From the perspective of learning practices, the quality of a student's learning is constrained firstly by the quality of their mastering-practice, and secondly by the extent to which context-related aspects of their learning practice constrain the exercise of that mastering-practice. This point flows from the interpretation of the outcome space of the study (see sections 11.2 and 11.3) and the observations that (a) it is only mastering-practice that is focused exclusively on the development of the requisite knowledge, understanding and skill; (b) that a student's learning practice in other contexts focuses on other issues (such as taking notes, or studying to perform well in a test) and does so in ways that may compromise the exercise of their mastering-practice; (c) that, at best, the compromise diverts students little from their mastering-practice; and (d) that, at worst, it completely bypasses the student's mastering-practice with practices such as rote learning or, with note taking, capturing-everything – practices that are significantly less effective in developing the requisite understanding and skill.

Point 7: The overall outcome space summarized as Figure 11.1 provides the basis for identifying constraints in the learning practices of students with demographics similar to those in this study. Each category of mastering-practice (except the most sophisticated) constrains learning by not explicitly affording the development of the level of understanding/skill afforded by more sophisticated categories. Other constraints are peculiar to the context. These points have already been argued in section 11.2.

Point 8: Once the nature of the variation in learning practices has been established (either by referring to the findings of this study or by conducting an independent study), a quantitative profile or distribution of learning practices in a cohort is needed in order to highlight aspects of learning practices that require particular attention. An effective way to profile students is to use a survey or an appropriate inventory instrument as discussed in section 11.6.

Point 9: The design of interventions, curriculum re-structuring or pedagogical measures that aim to help students to overcome constraints in their learning practices must facilitate an appropriate shift in practice by paying attention to the relevant distinguishing features of learning practices summarized in Table 11.1. More specifically, such interventions or pedagogical measures must aim to…

a) Facilitate an appropriate shift in conceptions;
b) Develop familiarity and skill with regard to the relevant resources and learning tools;
c) Facilitate the automatization of the new learning practice.

Each category of learning practice is characterized by a particular suite of distinguishing features such as specific intentions, conceptions, strategies, learning tools and dispositions. Accordingly, a shift in practice is associated with a corresponding shift in the associated elements, and pedagogical measures should be implemented to facilitate such shifts. Conceptions associated with the existing aspect of practice need to be transformed to or augmented by the conceptions associated with the new practice to be developed. In addition, the pedagogical measures should facilitate the development of the strategies or learning tools associated with the new practice.

Point 10: Pedagogical measures intended to modify learning practices or to develop new ones should be designed in accordance with the insights on the dynamics associated with changing learning practices that have been set out in section 11.4. Although these insights are idiosyncratic to the students involved in this study they may have relevance for other students and so should be given consideration.

PART C: IMPLICATIONS OF THE STUDY

Up to this point, this chapter has summarized and discussed the outcomes from the study. Part A drew together and discussed the findings of the investigations that were undertaken while Part B described three pedagogical tools – two models and a strategy – that were developed to interpret and use those findings for pedagogical purposes. This part of the chapter discusses the implications of these

outcomes particularly with regard to the concerns which motivated the study, namely the high rates of attrition of students entering our school and the possibility that problematic aspects of their learning practices may be a significant contributing factor. The discussion in the remainder of this chapter therefore focuses on the following questions.

- Is the quality of the learning practices of entrants to our school a significant factor influencing their rate of attrition by academic failure?
- If so, how do the learning practices of our students need to change in order to improve their academic prospects?
- How can our institution be more responsive to facilitating such change?

11.8 LEARNING PRACTICES AND ATTRITION BY ACADEMIC FAILURE

The premise behind the first of the questions posed above is that learning practices affect student attrition by the way they influence the quality of student learning and, consequently, the academic prospects of students; i.e. problematic features of students' learning practices contribute to poor academic performance and therefore to attrition by academic failure. This premise is supported in general by the conceptual framework of learning practices developed in the study (see section 11.1) which provides a detailed explanation of the role of learning practices in students' learning engagements. It is also supported more specifically by the model of the structure of understanding and skill that emerged from the study. That model makes direct links between different qualities of understanding/skill and different levels of mastering-practice which suggest that students who possess relatively unsophisticated levels of practice are likely to have low quality learning outcomes and so are more likely to fail academically than students with more sophisticated learning practices (see section 11.5). The study provided some empirical support for this contention in that the failure rate of our students in 2008 correlated with the level of sophistication of their mastering-practices as shown in Figure 8.3 and sections 6.3.3 and 8.7.

11.9 IMPROVING THE STUDENTS' LEARNING PRACTICES

The conclusion reached in the previous section – that there was a relationship between our students' academic performance and the quality of their learning practices – raises the question of what is needed for the learning practices of our students to change in order for their academic prospects to improve? Section 11.7 provides a strategy for answering such questions. To apply the strategy requires information about (1) the learning practices which students possess on entry, (2) the quality of practice needed to perform well academically, and (3) what is required in order for lower quality practices to develop into higher quality practices.

The study findings provide the latter two items of information directly. With regard to (2), the study has shown that the quality of practice which our first-year students should aim to develop should be the refinement level of mastering-practice and, if possible, the know-how level of practice. Other aspects

of their learning practice should be such as to minimize the extent to which their mastering-practice is constrained or attention is diverted from it. With regard to item (3), the study has shown that the way in which learning practices can develop from lower to higher levels of quality can be discerned by examining the outcome space of the phenomenographic study which outlines the typical qualitative variation in the learning practices found among the students (see Figure 11.1).

With regard to (1) – the learning practices of students on entry – the study has provided only a qualitative indication and that indication relates to the collective and not to individual students; it was beyond the scope of the study to provide quantitative information about how the learning practices of individuals in the cohort was distributed. However, a broad indication of the nature of this distribution can be developed from what was found about the learning practices of individuals in the sample of students. This indication is now presented in order to establish a basis for discussing how the study findings address the problem which motivated the study.

The students in the study have been profiled according to their mastering-practice (section 8.7), and from this profiling it was apparent that they could be grouped into three broad groupings based on level of sophistication – i.e. comprehension, consolidation and refinement levels of mastering-practice. However, the students were not profiled with respect to other types of learning practices and so assumptions had to be made. What was done was to focus on the level of sophistication rather than on the specifics of the different types of practices. In other words, it was assumed that level of sophistication was a general characteristic of an individual's learning practices so that the level of sophistication which is evident in one area of practice is likely to be similar to the level in other areas of practice. Accordingly, the three broad groupings associated with mastering-practice have been elaborated as shown in Table 11.4 and have been identified generally as, respectively, 'relatively unsophisticated', 'intermediate', and 'relatively sophisticated'. The table has simply selected from the categories of test-focused and learning management practices those categories that are relatively unsophisticated, intermediate and relatively sophisticated and these have been added to the relevant profiles in the table. With regard to classroom practices, there was uncertainty about how the different levels of sophistication in these practices were associated with the three groupings in the table so this aspect of learning practice was not been included in the groupings.

In the absence of profiles that have a stronger empirical derivation, and for the purposes of the ensuing discussion, it is assumed that individual entrants to our school fall into one of the three groupings described in the table. Based on personal experience of teaching entrants to our school for many years, such an assumption seems reasonable. Obviously, any recommendations that are based on these profiles can only be tentative until more reliable profiles are available. In any event, the table provides a basis for demonstrating how such profiles might be combined with the outcomes of this study to identify the developmental pathways which entrants to our school (and possibly to other engineering schools in South Africa) need to negotiate in order to improve their academic prospects and, based on

such information, to make recommendations about pedagogical measures that might be implemented accordingly. These issues are discussed in the sections which follow.

Table 11.4: Assumed Profiles of the Learning Practices of Three Groupings in the 2008 Cohort

Student Group →	**Comprehension Group**	**Consolidation Group**	**Refinement Group**
Level of Sophistication →	**Relatively Unsophisticated**	**Intermediate**	**Relatively Sophisticated**
The group's Mastering-practice	Comprehension level	Consolidation level	Refinement (and Know-How) level
The group's Test-focused practice	Pattern recognition and cramming	Strategic	Study normally, review work and past papers
The group's Learning management practice	Keeping at it	Keeping up	Keeping on top

11.9.1 The developmental pathways of the three student groups

With regard to improving learning practices, the developmental pathway of a student will involve shifting their practice from what it is on entry to at least a refinement level of mastering-practice and, more generally, from the relatively unsophisticated to the relatively sophisticated levels of practices indicated in Table 11.4. It is evident from the table that the developmental pathways of students in the three groupings are different.

The refinement group: Students in this group already possess the quality of learning practice considered to be a necessary prerequisite for good academic performance. However, these students would benefit from trying to develop their mastering-practice to the next level of mastering-practice – the know-how level. Other than this their only need is perhaps to reinforce and deepen their awareness of and the quality of their existing practice.

The comprehension group: The developmental pathways of students in this group can be identified as follows. In order to overcome the constraints on learning associated with a comprehension level of mastering-practice, the conceptions of the students need to shift in a number of areas and they need to develop familiarity and skill with regard to the relevant resources and learning tools. The specific shifts and developments that are needed can be discerned from Table 11.1 and are summarized as follows.

1) A shift from a conception of knowledge as comprehended theory to a conception of knowledge as consolidated and personally refined theory;
2) The development of consolidation tools – in particular the tool of *summarizing*;
3) The development of refinement tools – in particular the tools of conceptual *restructuring* and *connecting*;

4) A shift from a conception of problems as theory application problems to one that conceives them also as complex problems requiring heuristic problem solving skills;
5) The development of heuristic problem solving skills;
6) A shift from a conception that theory and problems are relatively independent aspects of a course requirement to a conception that they are mutually inter-related aspects of engineering understanding and skill. This is associated with the development of the integration level of mastering-practice.
7) Development of the highest level of mastering-practice (the know-how level) requires attention to (a) developing the conception that it is real world situations that give theory and problem-solving their relevance, and (b) developing the disposition to relate theory and problems to real world situations.

With regard to test-focused study practice, Table 11.1 would suggest that students in the comprehension group need conceptual shifts with regard to the objective of studying, what earns marks in tests, and the nature of knowledge and of mastering-practice. The need for conceptual shifts with regard to the merits and demerits associated with pattern-recognition, strategic study and cramming are also indicated. Developing awareness about the qualitative complexity of the knowledge, understanding and skill associated with the discipline of engineering, as opposed to its quantitative extent, should also help to promote the conceptual shifts mentioned so that students are not drawn to give undue attention to test-focused study strategies that divert attention away from trying to master the requisite understanding and skill.

With regard to learning management practice, Table 11.1 would suggest that the students need to become more aware that the qualitatively complex understanding/skill they need to develop requires incremental learning at a refinement level of mastering-practice and that *keeping at it* or even *keeping up* are not an adequate basis for organizing the appropriate study space and time. Linked to this, the development of more sophisticated scheduling practice should become a priority for them so that they routinely make available the appropriate time and space needed by refinement level study activities.

The consolidation group: The developmental pathways of students in this group overlap the pathways of the comprehension group just described. They differ with respect to starting point; where students in the comprehension group must negotiate the entire developmental journey just described, students in the consolidation group need to develop only the integration and refinement levels of mastering-practice and have already progressed beyond the relatively unsophisticated test-focused and learning management practices of the comprehension group. The developmental pathways of these students also differ with respect to the dynamics of change as discussed next.

11.9.2 Accounting for the dynamics of change

The starting points and extents of the students' developmental pathways are not the only factors that have to be taken into account by pedagogical measures designed to facilitate improvements in learning

practices. As indicated by Point 10 of the general strategy (page 152), account must also be taken of the dynamics that affect how learning practices change. In this regard, the three groupings of students are quite different.

The comprehension group: From the synthesis of insights presented in section 11.4 it is apparent that most students in this group are likely to be open to or are likely to be 'open to becoming open' to developing their learning practices once they become aware of the limitations of their current practice. In most cases, it is poor academic performance that is most forceful in bringing them to that awareness. In view of the extent of change which students in this group must negotiate, it is important that they develop this awareness as soon as possible and that appropriate instruction, materials and student support should be provided from early on in the year so that these students have available what is needed for them to begin the process of changing their learning practice when they become serious about wanting to do so.

The consolidation group: Here a different developmental problem arises. It appears from the study findings that if these students do make the effort to improve the quality of their learning practice they are likely to be successful in developing to the refinement level of mastering-practice. The problem with these students lies in the word 'if'! Only about half of the students in the study made the effort to modify their learning practice. It seems that with these students, the level of sophistication of their learning practice is high enough that it can mask their need to develop it further. Accordingly, the developmental problem here is to sensitise the students to their need for change and development – to engineer a 'wake-up call' – so that they come to the realization that serious attention should be given to changing their learning practice as a necessity for their academic success. As the most powerful instrument for engineering such a wake-up call appears to be poor academic performance in 'tests that count', challenging summative assessments early in the year are indicated for students in this group. Obviously care must be taken to make it clear to students that a primary motivation for the early assessments is for them to become aware as early as possible about the level to expect in tests/exams so that they can make any necessary adjustments to their learning practices. However, such early assessments should contribute to their final mark only to the extent necessary for an effective wake-up call to be engineered, and should not count so much that failure in the early assessments cripples their chances of passing.

The refinement group: Here a different kind of wake-up call is needed because these students do not appear to recognize that there is still room for them to develop their learning practice further – i.e. to the know-how level. To help students to gain this awareness, formative 'what if' or 'think about' exercises could be incorporated in tutorials or in lectures and possibly in tests as optional questions. The purpose of these formative measure should be made clear to the students; they should be presented as fore-runners to 'higher level, world-related' questions that will appear in tests/exams later in the year when

all students have had a chance to develop their learning practice to the extent needed to address such questions effectively.

11.10 RECOMMENDATIONS FOR PEDAGOGICAL MEASURES FOR IMPROVING THE QUALITY OF OUR STUDENTS' LEARNING PRACTICES

From the findings of this study it is hard to avoid the conclusion that unless a major investment is made towards improving the provisions in the first year curriculum for developing students learning practices, the current high rate of attrition is likely to continue. The need for such provisions is highlighted by the following observations and study findings.

- Many students need to modify their learning practices extensively and it is difficult for many of them to do so. The list of changes needed is quite considerable, especially for the comprehension group, and it is inherently difficult to modify existing practices because, generically, practices are ingrained in nature (see Part C of the previous chapter – page 134).
- It takes time for students to change their learning practices and, even more significantly, it takes time for them to come to a real awareness of the need to do so.
- The difficulty of making such changes is exacerbated by the pressured teaching and learning environment that is typical of first year engineering education. This pressure is intensified by any constraints on learning that are inherent in a student's current learning practice.
- The extent of change that can be expected during a student's first year at university with the current developmental strategy is quite limited. Where students in the study did show an improvement in the quality of their learning practice the extent of such improvement was, in all but one case, no greater than to the next most sophisticated category of practice when development to two, three or four higher levels of practice was possible.
- The limited improvement in the learning practices of our students occurred in a context which did give some attention to facilitating such development. Clearly, a different developmental strategy from the one currently in place in our school is needed.

The 10 point strategy presented in the previous section provides guidelines for the kind of pedagogical measures needed to facilitate improvement in the students learning practices. In this section, attention is given to the broader issues of the kinds of curriculum and teaching and learning environment that are needed in order for those measures to be most effective.

11.10.1 The general curriculum structure

The curriculum should provide for the development of the learning practices of all entrants to our school. The learning practices of many entrants are relatively unsophisticated and even in those cases where students have relatively sophisticated practices it cannot be assumed that these practices do not have problematic features.

Pre-selection and streaming of students according to the quality of their learning practices is not recommended because it is highly questionable that this could be done accurately or appropriately even though entrants may generally fall into one of the three groupings that have been described. In addition, the policy decision at Wits to move away from providing bridging, foundational or extended programmes as parallel or 'add-on' structures to the mainstream curricula mitigates against such pre-selection and streaming.

In order to ensure that the entrants give due attention to the quality of their learning practices and use appropriately the opportunities for developing learning practices which the curriculum provides, competency in learning practices should be an assessed learning outcome of the first year programme. In order to provide the time needed for new learning practices to become automatized, the developmental strategy should be year-long. Students are likely to revert to old practices when under pressure if insufficient time is allowed for any new aspects of a student's learning practice to become more or less as well automatized as existing practices.

11.10.2 An 'immersion' teaching and learning environment

The conceptual framework of the nature of learning practices developed in the study provides a basis for identifying the kind of environment needed for developing learning practices as quickly and effectively as possible. Practices are orientations that develop as a result of automatization processes that require repeated exercise of the relevant activities. As such, students need to be immersed in an environment in which the attention given to the development of learning practices is consistent and coherent and is sufficiently sustained and pervasive that the required automatization processes can occur. That environment should be as devoid as possible of factors that foster or reinforce problematic aspects of learning practices or that might cause students to revert to any of their old practices that are problematic. Where such problematic practices are particularly deeply ingrained – such as rote learning, for example – the teaching and learning environment should include 'counter-measures' whereby learning tasks force students to adopt other practices because it is patently clear to them that their old problematic practices will not be effective for those tasks.

In order to provide the kind of consistent and pervasive environment that has been described, all courses in the first year programme should be aligned with the developmental strategy and all teachers of these courses should be involved to some degree in that strategy otherwise it is likely to be undermined by conflicting messages or requirements. A traditional stand-alone 'skills course' is not recommended because, in the context of a single course, it is inherently difficult to achieve the kind of broad and consistent immersion described. However, it may be appropriate, in an across-the-curriculum strategy, for the instruction on learning practices to be provided in one module as long as that module and the other courses in the first year programme are integrated with regard to the overall strategy for developing students' learning practices.

Finally, the immersion approach should not only be integrated across-the-curriculum in the manner described, it should also be appropriately contextualized; the attention to learning practices should be given in the context of disciplinary content and, if appropriate, should be integrated with that content. The rationale here is that practices are contextual in nature – they are developed in and relate to specific contexts.

11.10.3 Pedagogical measures

With regard to the modification of students' existing learning practices and the development of new ones, measures are required that guide and support students along the developmental pathways that were described in the previous section. Some combination of instruction and the reading of texts is required for bringing the relevant conceptual issues to the students' attention in preparation for thinking about and exercising the various aspects of learning practices identified there (see section 11.9.1).

In order to contextualize the development of learning practices appropriately, the structure of the various components of the teaching and learning environment – lectures, tutorials and laboratories – should be redesigned with an eye to how these components influence the development and reinforcement of the desired learning practices. This recommendation amounts to having a dual focus when implementing each component of the teaching and learning environment – i.e. the intended learning of disciplinary knowledge/skill and the development of desired learning practices. If implemented appropriately, this dual focus should be synergistic. For example, in problem solving, students could examine the impact of changed circumstances on a problem solution, or could reflect on the heuristics involved. Such activities would not only enhance the quality of learning but would exemplify and reinforce the development of relevant learning practices.

Another way of maintaining the dual focus just described is to introduce a system of 'in-course mentoring' in which tutorials (or their equivalents) would include, as part of their structure, regular interactions with 'learning-practice mentors' – mentors trained to engage with students in regard to their learning practices. Obviously space would need to be made in these tutorials for this additional activity. Apart from ensuring that an appropriate focus on learning practices is maintained over the duration of a course, regular engagement with such mentors will provide assistance to the students in thinking about and developing their learning practices. In-course mentoring could also provide the flexibility in the curriculum needed to address the diversity of students' developmental needs. For example, the extent of development needed and the associated dynamics are different for each of the three groupings of students that have been identified and the in-course mentoring system could cater to the different needs of students in these groupings.

A critical requirement of the pedagogical measures is that they must sensitize students to their need to pay attention to the development of their learning practices. This is particularly important for those students who may be blinded to their need because they do not realize the extent to which their

academic success at school was based on learning practices that are not conducive for success at university. For such students the pedagogical measures must engineer the appropriate 'wake-up call'. The study has shown that while instruction given at the beginning of the academic year may sensitize a few students to their need to pay attention to improving the quality of their learning practices, many require more drastic measures if they are to become appropriately sensitized. The study has shown that poor academic performance in 'tests that count' seems to be a particularly effective way to engineer the needed wake-up call. Accordingly, thought should be given to scheduling major tests at the end of the first quarter. The tests should contribute to the final mark sufficiently that students take them seriously, but not so much that failure cripples their academic prospects.

The final recommendations have to do with teaching. Given the argument that problematic features of students learning practices are an important cause of student attrition among our entrants, the teaching of first-year students should be regarded as a speciality that requires expertise in developmental education, particularly with respect to learning practices. To be effective, teachers in the first year programme need to be deeply aware of the issues raised in this thesis and should be skilled in implementing the kind of measures that have been described.

CHAPTER CONCLUSION

This chapter has compiled the results of the study and has discussed their pedagogical implications as a whole. The next chapter concludes the thesis with a consideration of the limitations of the study, recommendations for further research, how the study findings resonate with the literature, and a summary of the theoretical developments that have emerged from the study.

CHAPTER 12: CONCLUSION
THE QUALITY AND CONTRIBUTIONS OF THE STUDY

To draw this thesis to a conclusion the issues of the quality, limitations and contributions of the study are discussed and recommendations for further research are made. This is done in Part A of the chapter. Part B discusses the study findings from the perspective of the literature and the theoretical developments which have emerged from the study. Part C reviews the implications of the study and the significance of what it has achieved.

PART A: THE QUALITY OF THE STUDY AND RECOMMENDATIONS FOR FURTHER RESEARCH

12.1 RIGOUR AND TRUSTWORTHINESS OF THE RESEARCH

The consensus that appears to have emerged from the literature in regard to the issues of rigour and trustworthiness in a phenomenographic study identifies three criteria that a study should satisfy – i.e. credibility, dependability, and transferability. Chapter 4 explained these criteria in detail (section 4.1.4). In this section, the rigour and trustworthiness of the study is examined in the light of those criteria.

With regard to the criterion of credibility, the study was executed by someone (myself) who is deeply familiar with the subject matter as indicated in the prologue (content-related credibility). With regard to credibility of method, the research was conducted after considering the appropriateness of phenomenography for the proposed study, and tailoring the research methodology and design accordingly as indicated in Chapter 4 and following carefully the methodology set out there. With regard to communicative credibility, there have been on-going discussions with phenomenographers at critical points in the study. This, along with the process for examining the thesis, provides reasonable assurance of conformity to this aspect of the credibility criteria.

With regard to the criteria of dependability of the study findings, the various dependability checks suggested in section 4.1.4 were carried out – namely the piloting of the interview protocols and the 'double process' of checking the accuracy of interview transcripts. The 'double process' dependability check in regard to the quality of the data analysis was not possible given the single researcher context of a PhD study, but supervision by an experienced phenomenographer does go some way in meeting this criterion. The same comment applies to the criteria of transferability.

One aspect of the study that could attract criticism is in regard to the credibility criterion of the "correspondence between the way the respondents actually perceive social constructs and the way the researcher portrays their viewpoints" (Mertens & McLaughlin, 2004 p106 cited in Collier-Reed, Ingerman, and Berglund, 2009). Because practices involve a degree of intuitive processing, it was

generally not easy for the student, never mind the researcher, to access and articulate the tacit aspects of their practices. Dreyfus (2005) alludes to this difficulty in regard to experts finding it almost impossible to articulate adequately the tacit aspects underlying their expertise. Accordingly, in the study, the identification of the conceptions behind the intentions and strategies that underlie the students' learning practices were perhaps more dependent on the researcher's interpretations than is usual in a phenomenographic study. However, this is an implicit difficulty in researching practices more than a shortcoming of the study. In an attempt to overcome this difficulty, two courses of action were taken. The first was always to support researcher interpretations of conceptions with actual interview extracts (to an extent that is perhaps excessive in a thesis). The second was to tie the interpretation of conceptions as closely as possible to the intention or strategy which they influenced. For example, in a consolidation-oriented study practice, the interpretation of the conception of knowledge behind the intention to consolidate theory was interpreted as 'consolidated theory'.

12.2 LIMITATIONS OF THE STUDY

This study embraced a wide range of learning practices but concentrated particularly on study practices and their influence on the quality of learning. Consequently, some aspects of learning practices were not investigated to the same degree as others and further research is indicated in these areas. Specific aspects that warrant such attention include the influences of motivations, dispositions, and educational and circumstantial backgrounds on study prioritization and learning practices. In addition, the practices of learning management, help-seeking, and studying in groups could be researched in more depth and the way they influence the quality of student learning could be investigated further.

During the study, several aspects of learning practices were exposed as being particularly important but the available data was not sufficiently detailed or was not of the kind that allowed the degree of in-depth analysis that seemed called for. Three aspects in particular stand out: conceptions of knowledge and the nature of problems; the integration of the learning of theory and the solving of problems; and the differentiation between theory-application problem-solving and heuristic problem solving. Further research of these aspects of learning practices is indicated.

Some aspects of learning practice were not investigated in sufficient detail because of constraints imposed by the scope of the study and by the research design. One limitation is that the findings were based only on what students said and not on observations of their practices. This is the result of taking a second order perspective on learning practices, a perspective that is a central feature of the phenomenographic methodology; it is common practice to base a phenomenographic study on interviews alone. An addition limitation is that an in-depth investigation into the dynamics associated with students changing their learning practices would require more data and additional kinds of data than that gathered in this study. Further, when probed about their reflective and their self-regulation practices students were generally rather superficial in their responses. It was not possible to probe these issues in more depth because the time available for interviewing students was limited and there were

many other aspects that needed to be addressed in that time. To investigate these aspects of learning practices would require different research designs that are more focused on each of these aspects of learning practice.

12.3 ADDITIONAL INDICATIONS FOR FURTHER RESEARCH

The practice perspective on student learning which this study has developed opens up many avenues for further research. These include the development of the descriptive model (section 11.6) into an instrument for profiling the learning practices of students; further research on the veracity of 'the structure of understanding and skill' developed in the study as a means of describing and evaluating the quality of student learning; the evaluation of the strategy for improving students' learning practices (section 11.7) with regard to its efficacy as a tool for designing interventions focused on the learning practices of students; and further research on how students' learning practices change and on the usefulness of the concept of 'learning tools' as conceived in the study.

PART B: THE STUDY FINDINGS FROM THE PERSPECTIVE OF THE LITERATURE

Chapter 2 outlined two perspectives on student learning that are prominent in the literature – self-regulated learning (SRL) and student approaches to learning (SAL). This study has developed a third perspective – the perspective of 'learning practices'. This new perspective has more affinity with the SAL tradition than with the SRL tradition, being grounded in the phenomenographic tradition and striving to see learning practices from the point of view and experience of the students. Accordingly, the consideration of how the study findings resonate with the literature will focus only on the SAL literature.

12.4 THE STUDY FINDINGS FROM THE PERSPECTIVE OF THE SAL LITERATURE

12.4.1 Points of correspondence with the SAL tradition

The study findings on learning practices resonate with the SAL literature at many levels. They both focus on variation, intentions, strategies and the structure of awareness behind the way students relate to aspects of studying and learning. The distinction between surface and deep approaches to learning, which is a hallmark of the SAL tradition, is reflected in the study findings with regard to the distinction between studying-for-tests and mastering-practice. The parallel is close but not exact, as discussed shortly. The surface/deep distinction is also reflected in the study findings in that comprehension and consolidation levels of mastering-practice were found to be vulnerable to being influenced towards rote learning – that is towards a surface approach to learning – and also in that the refinement and know-how levels of mastering-practice are typically associated with learning engagements that SAL would describe as being deep in nature. There are also several points of resonance with regard to some of the more detailed insights of the SAL tradition. These include the following.

The influence of conceptions of knowledge and of learning: The SAL literature has sometimes invoked the work of Perry (1970) as indicating a variation in conceptions of knowledge or, more precisely, as a variation in epistemological levels (Entwistle, 2000, 2004) and has associated this variation with the variation in conceptions of learning where less sophisticated conceptions are associated with a surface approach to learning and the more sophisticated conceptions with a deep approach. This study found a similar kind of association: a relatively low level of sophistication with regard to conceptions of knowledge-type being associated with the less sophisticated levels of mastering-practice, and a higher degree of sophistication of the conceptions being associated with the more sophisticated levels of mastering-practice.

The issue of memorization: The findings of this study agree with the consensus that has emerged in the SAL tradition with regard to the distinction between memorizing with and without understanding and the respective influences on the quality of learning engagements. For example, although memorization is frequently associated with a surface approach, it has been shown, particularly among Chinese and Asian learners, that it can also be associated with an intention to understand and, when that is the case, is indicative of a deep approach to learning (Marton et al., 1995). Similar associations were found in this study: memorizing information was found to be associated with rote learning, and 'memorizing with understanding' was recognized as a more sophisticated practice – a consolidation-oriented study practice – that was generally related to a deeper level of understanding.

Conceptions of the complexity of understanding: Entwistle's work on the variation in ways students attempt to develop complex understandings (Entwistle & Entwistle 1997, 2003; Entwistle 2009; McCune & Enwtistle 2011; Entwistle & Marton 1994) resonates with the refinement-oriented study practice described in this study. The concept of 'knowledge objects' used in this thesis when describing the kind of integrated knowledge associated with refinement practices derives directly from that work.

Theory and problem-solving: The distinction between the learning of theory and the solving of problems is evident in the SAL tradition, particularly in the work of Crawford et al. (1994) – see Table 2.4. However, the distinction is not as stark in the literature as it is in the findings of this study.

The influence of prior experience: The position of the SAL tradition on the role of prior experience in influencing student learning is perhaps most clearly and succinctly articulated by Prosser and Trigwell in the following quotation.

> "[In a situation] in which the context affords a surface approach … [and is engaged by] a student whose prior experiences have been in terms of a deep approach …[the] student is likely … to adopt a surface approach. However, it is also possible for such a student to transcend … his or her situation and adopt a deep approach. The completeness (or inclusiveness) of the student's prior conceptions of learning and approaches to study make it possible for this student in this situation, but not for students with prior experience involving limited (less inclusive) conceptions and approaches to learning." (Prosser & Trigwell, 1999, p. 20)

The idea expressed in this quotation, that a student's past experience constrains their options when they engage in learning tasks, accords well with the conception of the dynamics of learning engagements as

described in the conceptual framework developed in this study. The SAL position on this matter is similar but is not developed in as much detail; more will be said in this regard shortly.

Ramsden (Entwistle & Ramsden, 1983; Ramsden, 2003) reported finding that, in comparison to the influence of the learning context, the association between prior experience and a student's approach to learning is relatively weak. However much this finding may be valid for the students involved in his studies, there is quite strong evidence to the contrary with regard to South African students both in the Simelane (2007) study and in the work of Meyer and colleagues (for example see Meyer et al., 1990; Meyer et al., 1994; Meyer et al., 1992; Meyer & Parsons, 1989). This study has demonstrated a rather strong relationship between academic performance and the quality of a student's learning practices developed prior to entry to university.

The model of student learning: The perspectives on the nature of student learning that have emerged from this study and from the SAL tradition (in particular the '3P model') are more or less in agreement with regard to the general way that they trace a line of influence from the quality of prior experience to the quality of learning engagements to the quality of learning outcomes. However, this study established a more detailed perspective as discussion in the next section.

In summary, the many points of correspondence between the study and the SAL tradition suggest that the findings of this study are generally in line with an extensive and well-established body of research.

12.4.2 Points of divergence from the SAL tradition

The most prominent divergence of the study findings from the SAL conceptual framework is a shift from the surface-deep distinction being regarded as the decisive issue in determining the quality of student learning to a position where two issues are considered decisive – the quality of a student's mastery-practice being the primary issue and the second being the extent to which the student's other practices, each related to a particular learning context, constrain the exercise of their mastering-practice. This shift has four roots:

- A more detailed conception of the dynamics of learning engagements;
- An emphasis on learning practices;
- The recognition that understanding and skill are multi-layered and complex in nature so that even if a student does adopt a deep or mastering-oriented approach to learning the quality or 'depth' of the outcome of that learning can be quite variable;
- The recognition that, in addition to the tendency to adopt reproduction-oriented approaches when tests are looming, a range of factors may constrain or divert a student from the exercise of their most sophisticated mastering-practices.

From the perspective of the findings of this study, the way that a surface approach to learning has become generalized as 'learning-for-reproduction' is seen as both an oversimplification and a

confusion. It is seen as an over simplification in that it ignores the complexity of what a deep understanding entails – it conflates comprehension, consolidation, integration, refinement and know-how levels of understanding and skill. And it is viewed as a confusion in that the focus on reproduction and recall generally associated with 'a surface approach' is seen either as a context-forced diversion from the mastery-oriented approach which a student is potentially capable of adopting or as the possession of relatively unsophisticated mastering-practices such as information-oriented study practice. Outside of the context of having to deal with assessment processes, the idea of a surface approach loses its force. Even in the context of impending assessments, a student's relation to studying and learning may be multilayered in nature and can involve aspects other than 'learning for recall and reproduction' – aspects such as strategic studying and a pattern recognition mode of studying past papers.

A further critique of the SAL view of student learning is that too much hinges on the surface-deep distinction. For example, taking Prosser and Trigwell's articulation of the 3P model, a student's prior experience and their perceptions of what a learning environment affords are all evaluated on the basis of the surface-deep dichotomy. From a learning practice perspective and the criticisms made above, this perspective seems a problematic over-simplification.

12.5 THEORETICAL CONTRIBUTIONS OF THE STUDY

Although this study did not set out to develop new theoretical positions, it has done so in a number of areas. The various divergences from SAL positions and the critique of the surface-deep distinction that have been articulated above are not the only theoretical contributions which this study has made. Others include the following.

The construct of a learning practice: This study has elaborated Dahlin's interpretation of Peirce's model of cognition to develop a conceptual framework of the nature of 'learning practice' as a technical term rather than as a gloss for 'ways of engaging with studying and learning'.

A practice perspective on student learning: The study has developed a conceptual framework of the nature of learning engagements and of how these are influenced by 'learning practices' and the contexts of the learning environment.

Categories of variation in students' learning practice: The outcome space from the investigation into the variation of the students' learning practice identifies categories of practice that, from the perspective of the literature, are novel. As such, they are of general interest in the domain of higher education research and may very well have applicability beyond the context in which they have been developed.

A structure of knowledge and know-how: The 'structure of knowledge, understanding and skill' that has emerged from the study is novel. It provides a general means of characterizing the quality of understanding and skill developed by engineering students.

The construct of a 'learning tool': The concept of a 'learning tool' that has emerged from the study is novel. Its potential as a means for helping students to improve the quality of their learning by improving their learning practice is quite general and is not restricted to the specific context of the study.

PART C: CONCLUSION: WHAT THE STUDY HAS ACHIEVED

While the theoretical ramifications of the learning perspective on student learning that have emerged from this study are interesting and may prove to be quite important, the primary purpose of the study was practical. As outlined at the beginning of the thesis (section 1.4), the severity of the problem of high first-year attrition rates among first year students in South Africa is sufficiently extreme that, for example, Letseka and Maile (2008) suggested it threatens the future of the country. The study set out to gain insight into the learning practices of our entrants and, more generally, of entrants to engineering education in the country, as a way to move towards more effective strategies for reducing attrition and improving student learning in first year than those which are currently in place.

From the perspective of the literature, 'learning practices' as a unit of analysis in research on student learning and attrition is novel. It constitutes a departure from the two dominant research traditions of self-regulated learning (SRL) and student approaches to learning (SAL). Accordingly, the study necessarily involved a certain amount of conceptual development both in terms of a conceptual framework for the nature of learning practices and their role in student learning, and an interpretive framework for relating the quality of a learning practice, once described, to the quality of the learning which it afforded. Accordingly, the outcomes from the study include both these conceptual developments and the results and implications of the investigations into the nature of the learning practices of our students. In summary, therefore, the contributions to knowledge which the study has made can be listed as follows.

1) A conceptual framework of the nature of learning practice and its role in student learning.
2) A description of the nature of the learning practices of students entering engineering education in the country as represented by the students entering the school of chemical and metallurgical engineering at Wits.
3) A practice-based strategy for improving the quality of student learning by improving the quality of their learning practices.

The study has also yielded detailed reasons and remedies for the high levels of attrition among our entrants. In summary, these are as follows.

There are three broad groupings of students in the class that are distinguished by the level of sophistication of their learning practices. Indications from the study are that students who enter university with sophisticated learning practices generally do well academically and none are likely to

fail. Students with a rather unsophisticated level of practice are unlikely to appreciate the nature of the complex knowledge which they must master in order to be academically successful in an engineering program. The unsophisticated nature of their learning practice inherently constrains their learning of this complex knowledge and, consequently, their chances of passing first year are not good unless they improve the quality of their learning practice significantly. These students generally appear to be open to working on improving their learning practices and so are amenable to help in this regard. If effective pedagogies can be implemented to help these students in these endeavours, the prospects of achieving a significant improvement in the levels of their academic performance are good. The nature of these pedagogies and the consequential re-structuring of the curriculum which they require are quite radical. The study has made a number of recommendations about the kind of pedagogies and curriculum modifications that would be needed.

With regard to the remaining grouping of students, those who enter university with an intermediate level of sophistication in their learning practice, the chances of passing are better than for the comprehension group but are still not good. The problem with these students is not just that the level of their learning practice is not sufficiently sophisticated to develop the kind of complex understandings and skill needed to pass, but that many of these students are not receptive to measures that could help them to improve their learning practice. The evidence suggests that students in this grouping seem quite capable of improving their learning practice to an appropriate level of sophistication if they become aware of the need to do so. However, it appears that about half of them typically do not become aware of this need and so remain at risk of failing. Accordingly, in order to improve both the retention of these students and the quality of their learning, appropriate sensitization measures need to be included with the pedagogical measures to facilitate the development of more sophisticated learning practices. Again the study has made recommendations for the kind of measures needed.

In conclusion, the study has found a strong relationship between the quality of our students' learning practices and the quality of their learning. It has also shown that many students enter our school with learning practices that predispose them to failure. Although further work is needed to corroborate these findings, their implications are significant. They suggest that, unless pedagogical measures and curriculum restructuring of the kind recommended in the study are implemented, it seems unlikely that the academic prospects of these students can be improved to any significant degree because of the way in which their learning is constrained by their learning practices.

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APPENDIX A: INTERVIEW PROTOCOLS

Protocol for the first round of interviews

Introduction *(Introduction to explain the context and nature of the interview to the interviewee)*
"Thank you for volunteering to being interviewed. First I want to tell you what we're going to do. What I'm trying to find out is how students who come to our programmes have experienced learning before they come to university. I'm interested in everything to do with their prior experience of teaching and learning because this can help us to improve what we do in first year chem/met eng here at Wits. As said, the interview will be recorded but everything will be anonymous – only the few people on the research team will see the record of the interview and your name will not appear on that record. We're not going to tell anyone about who has been part of this research study. We may have some follow up questions and we would like to have a follow up interview later in the year. But you can withdraw from this research process at any point without prejudice. Is that OK with you?"

"Thank you. So I'm going to ask you a number of questions so that we can have a conversation about the experience of learning." [Maybe a lead in Question such as "Tell me how school was for you – what was your favourite teacher like."]

Question 1: What was your favourite subject at school?
Example follow-up questions:
Why was it your favourite subject?
How do you go about learning it?
How did you know when you understood something?
What did you do when you didn't understand something?
How was your teacher on that subject?
How did you study for matric in that subject?
What is learning?

Question 2: What was your least favourite subject at school?
Example follow-up questions:
Why was it your least favourite subject? Why didn't you like it?
It must have been tough for you studying that you didn't really like. How did you do that?
What did you do when you didn't understand something?
How was your teacher on that subject?
How did you study for matric in that subject?

Question 3: To what do you attribute your success in matric?
Example follow-up questions:
How did you prepare for matric – science, English, maths?
What did you do when you sat down to study?
How did you know when you understood something?
What about your teachers – how important were they to your success? What role did they play in your success?
How are you going to cope without them?
[Possible Question: Did you ever think about how your teachers expected you to go about learning? If so what did you think?]

Question 4: What are your expectations of teaching and learning here at Wits?
Example follow-up questions:
How are you coping?
How are you coping with the freedom here? Of everything being left up to you?
What do you see as possible pit falls ahead of you?
Why did you choose Wits? How is it meeting your expectations?

[Possible Question 5: What advice would you give to a student entering their matric year about what they should do?]

Protocol for the second round of interviews

Question Set 1

	Question	Intention of the Questions
1	How comfortable/satisfied are you now about the way you go about studying and learning NOW?	To establish the degree of confidence and affective status of students towards their current learning practices.
2	Tell me about how you have gone about learning and studying this year?	To establish the nature of the students learning practices near the end of their 1st year experience.
3	Were there any differences in the way you learned in Process and in other courses? If so how and why do you think you went about learning differently?	
4	How would you describe learning in general terms? What is learning? Understanding? Studying?	
5	Can you think back over your experience here at Wits. Is there any difference in the way that you go about learning and studying now and the way you did at the beginning of the year? If so tell me about the differences.	To explore the students perceptions about how their learning practices have changed during the first year.
6	Now can you think back further. Is there any difference in the way that you go about learning and studying now and the way you did at school? If so tell me about the differences.	
7	Can we go back to the issue of learning. To what extent has your understanding of learning, understanding and studying changed during the year? (Picking up on Q4)	
8	I want to go over some of your responses to the questionnaire on your experience of the Process course. In response to the question … you wrote … Could you tell me more about that.	To explore how students responded to different aspects of the Process course particularly those aspects designed to develop/enrich learning practices.
9	Imagine that someone from your old school who has the same background as you is coming to do chemical/metallurgical engineering at Wits next year. What advice would you give them to help them do well? What advice would you give them in regard to how to go about studying and learning?	To explore further student perceptions about what constitutes effective learning practices.
10	Knowing what you know now, would you have done things differently at the beginning of the year? If so, what would you have done differently?	
11	Educators often say that a student needs to reflect on how s/he learns and to think about what is working and what is not working when s/he is learning and studying. To what extent do you do that? (with follow-up questions for elaboration).	To explore the meta-cognitive practices of students.

Question Set 2

12	Here are some things which some of your class mates have said about learning at school. On a scale of 1 to 10, to what extent do these apply to you? (1 is "it doesn't apply at all", 10 "it applies completely".)	**SCORE**
	a) At school I enjoyed learning.	
	b) For me, matric was easy.	
	c) In matric, there was not much time pressure – I generally had a lot of time – for me, time for study was not a major constraint at school.	
	d) In matric, I had a well-established system for studying and learning.	
	e) My system of studying and learning in matric was manageable and it worked for me.	
	f) School for me was comfortable and relatively stress free.	
	g) I now realize that at school I relied a lot on the systems the school provided for me – like teachers always being available for support, extra classes, always someone I could go to if I had a problem.	
	h) School did not provide me with good teaching and support systems – I had to rely on myself to organize my learning, study groups, study mates, study guides etc.	
	i) Doing past papers was an extremely important factor in my success at school.	
	j) I now realize that I did not have to do much to organize my study time at school. All I had to do was my homework and to study for tests and exams when these came up.	
	k) Because my home language is not English, I often found it helpful at school to switch backwards and forwards between my mother tongue and English.	
	l) My only goal in matric was getting a good university pass.	
	m) At school I wasn't so much motivated to learn for the sake of learning.	

Question Set 3

13	Now, to finish, can we come back to how you learn and study NOW. You've talked about this already, but I want to get the big picture now. **Please tell me and explain the extent to which the following learning and studying activities play a major part in the way you learn and study NOW.** *(As appropriate, ask follow-up / elaboration questions in regard to how the student may have changed in these areas over the year.)*	
13.1	**Detailed Study Practices** a) Studying by reading my notes, textbooks, class hand outs. b) Writing notes as I study –i.e., condensed notes, summaries, lists, mind maps. c) Doing problems to develop my problem-solving skills. d) Doing problems as a way to deepen and check my understanding of what I have learned.	
13.2	**General Approach to Learning** a) Just memorizing, cramming, drilling stuff into my head. b) Learning formulas, when and how to apply them. c) Trying to understand the concepts, what they mean, how they relate to other concepts, looking for connections, getting "the big picture". d) Focusing mainly on what I think will come up in tests.	
13.3	**On-going Study Strategy** a) Preparing for classes in advance. b) Reviewing my notes as soon after a lecture as possible. c) Reviewing my work on a regular basis.	
13.4	**Reflection** a) Thinking about how effectively I am studying as a way of keeping my studies as focused as possible. b) Thinking about how I am understanding things while I am studying.	
13.5	**Study Organization** a) Being systematic and organized in the way I study. b) With regard to preparing for tests, planning ahead so that my study schedule for other subjects is not affected very much (… so that, in the week or so before an upcoming test, I do not ignore my other subjects).	
13.6	**Time and Self-Management** a) My general time management – organizing and prioritizing my time well. b) Being disciplined about such things as avoiding time wasters, sticking to my study and time management plans, concentrating when I study. c) When it is time to study, being disciplined about getting down to it. d) Avoiding or managing things that stress me.	

APPENDIX B: FOLD-OUTS OF KEY TABLES AND FIGURES

Table 6.1: Variation in Theory-Focused Study Engagements: The Outcome Space

Level	Category	Description	Knowledge type intended to be developed: + agency/resources used
1	Information oriented engagements	Study engagements oriented to learning facts, formulae, or information by assimilating, memorizing, or cramming[1] that information with no particular regard for its meaning or relevance.	Learned information: Resources used = texts[2]
2	Comprehension oriented engagements	Study engagements oriented to making sense of course material by reading through it, going through it, or working through it in order to develop personally comprehended theory with no particular regard for consolidating or restructuring the material as it is presented in the course.	Personally comprehended theory: Resources used = texts[2]
3	Consolidation oriented engagements	Study engagements oriented to consolidating or reinforcing personally comprehended theory by using consolidation tools such as highlighting, vocalizing, memorizing, summarizing, or applying theory in order to develop personally consolidated theory with no particular regard for refining it beyond the content or structure presented in the course.	Personally consolidated theory: Resources used = texts[2], and consolidation tools
4	Refinement oriented engagements	Study engagements oriented to deepening personal mastery of consolidated theory by refining it using refinement tools that restructure and make new connections by means of techniques such as elaborating, self-questioning, restructuring notes, concept maps, or visualizing in order to develop a personally refined grasp of disciplinary knowledge with no particular regard for how these relate to real world situations.	Personally refined theory: Resources used = texts[2], consolidation and refinement tools
5	Know-how oriented engagements	Study engagements oriented to deepening personal mastery of disciplinary knowledge by relating it to real world situations in order, implicitly or explicitly, to develop practical know-how.	Personally developed disciplinary know-how: Resources used = as above plus relevant real-world knowledge

[1] Cramming is a reproduction-oriented study practice but it uses strategies similar to assimilating.
[2] Texts consist of course material contained in textbooks, class hand-outs, or notes taken in class.

Table 6.2: Variation in Theory-Focused Study Practice: The Outcome Space

	Category	Description	Strategies Used and Thresholds*	Knowledge type intended to be developed: [Resources used]
1	Information oriented practices	Oriented to learning facts, formulae, or information by assimilating, memorizing, or cramming that information with no particular regard for its meaning or relevance.	Assimilating Memorizing Cramming 1	Learned information: [Texts]
2	Comprehension oriented practices	Oriented to making sense of course material by reading through it, going through it, or working through it in order to develop personally comprehended theory with no particular regard for consolidating or restructuring the material as it is presented in the course.	Reading through Going through 2 Working through 3	Personally comprehended theory: [Texts]
3	Consolidation oriented practices	Oriented to consolidating or reinforcing personally comprehended theory by using consolidation tools such as highlighting, vocalizing, memorizing, summarizing, or working problems in order to develop personally consolidated theory with no particular regard for refining it beyond the content or structure presented in the course.	Highlighting Vocalizing Memorizing 4 Summarizing 5 Applying	Personally consolidated theory: [Consolidation tools and texts]
4	Refinement oriented practices	Oriented to deepening personal mastery of consolidated theory by refining it using refinement tools that restructure it and make new connections by means of techniques such as elaborating, self-questioning, restructuring notes, concept maps, or visualizing in order to develop a personally refined grasp of disciplinary knowledge with no particular regard for how these relate to real world situations.	6 Restructuring Making connections	Personally refined theory: [Consolidation and refinement tools and texts]
5	Know-how oriented practices	Oriented to deepening personal mastery of disciplinary knowledge by relating it to real world situations in order, implicitly or explicitly, to develop practical know-how.	7 Relating	Personally developed disciplinary know-how: [the above plus real-world knowledge]

* Thresholds associated with constraints on learning are indicated by the dashed lines and circled numbers

Table 7.1: Variation in Problem-Focused Study Practices: The Outcome Space

	Category of Practice and Thresholds*	Description of Problem-Focused Study Practice	Distinguishing Features.
1	Familiarization practice	Oriented to engaging with worked-examples to develop or deepen the appropriate procedural knowledge and skill by means of studying the worked-examples carefully.	Task-type: *Familiarization task* Problem-type: *Worked-example* Skill-type: *Procedural knowledge/skill* Strategy-types: *Studying worked-examples*
	Memorization-oriented Practice (Subcategory of the above)	Oriented to engaging with worked-examples to develop or deepen the appropriate procedural knowledge by mean of studying the worked-examples carefully and committing them to memory.	Task-type: *Familiarization task* Problem-type: *Worked-example* Skill-type: *Procedural knowledge* Strategy-types: *Studying worked-examples* *Memorizing procedures*
2	8a Formula-application practice	Oriented to engaging with problems which are experienced as formula-application problems and engaging with these to develop or deepen formula-application skill by means of studying worked-examples and practicing problems.	Task-type: *Calculation task* Problem-type: *Formula-application problem* Skill-type: *Formula-application skill* Strategy-types: *Studying worked-examples* *Practicing problems*
3	8 Theory-application practice	Oriented to engaging with problems which are experienced as theory-application problems and engaging with these to develop or deepen theory-application skill by means of understanding theory, studying worked-examples, practicing problems, and, where appropriate, applying relevant formulae.	Task-type: *Theory-application task* Problem-type: *Theory-application problem* Skill-type: *Theory-application skill* Strategy-types: *Studying the theory* *Studying worked-examples* *Practicing problems*
4	9 Problem-solving practice	Oriented to engaging with problems which are experienced as complex problems and engaging with these to develop or deepen problem-solving skill by means of reflecting on solution methods in addition to strategies used for the previous category.	Task-type: *Skill-development task* Problem-type: *Complex problem* Skill-type: *Problem-solving skill* Strategy-types: *As for category 3* *Reflecting on methods*
5	World-application practice	Oriented to engaging with problems which are experienced as world-application problems and engaging with these to develop or deepen world-application skills by means of reflecting on relevance to real world application in addition to strategies used for the previous category.	Task-type: *Skill-development task* Problem-type: *World-application problem* Skill-type: *World-application skill* Strategy-types: *As for category 4* *Reflecting on relevance*

* Thresholds are indicated by the circled numbers and dotted lines.
The numbering of constraint threshold 8a is different from the rest because it is conceptually derived rather than having been specifically reported by any of the students.

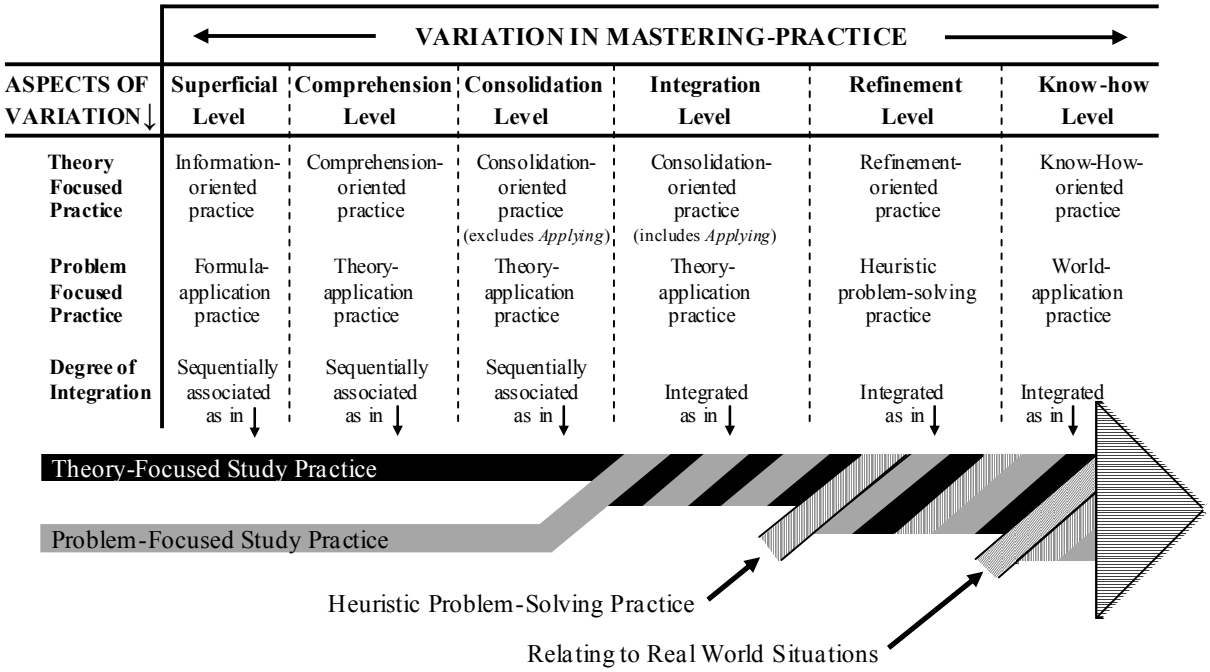


Figure 8.1: Variation in Mastering-Practice

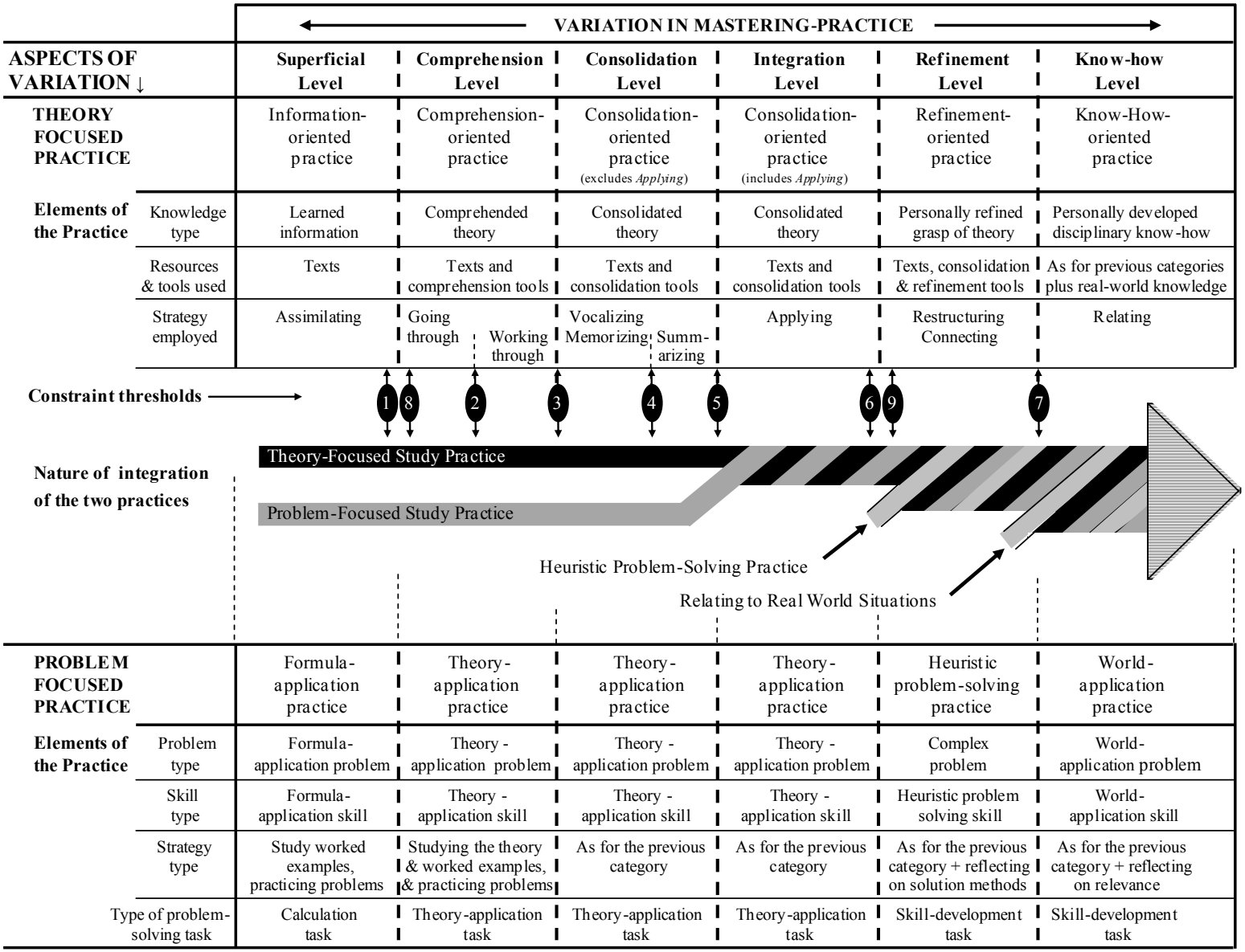


Figure 8.2: Graphical Representation of the Variation in Mastering-Oriented Study Practice

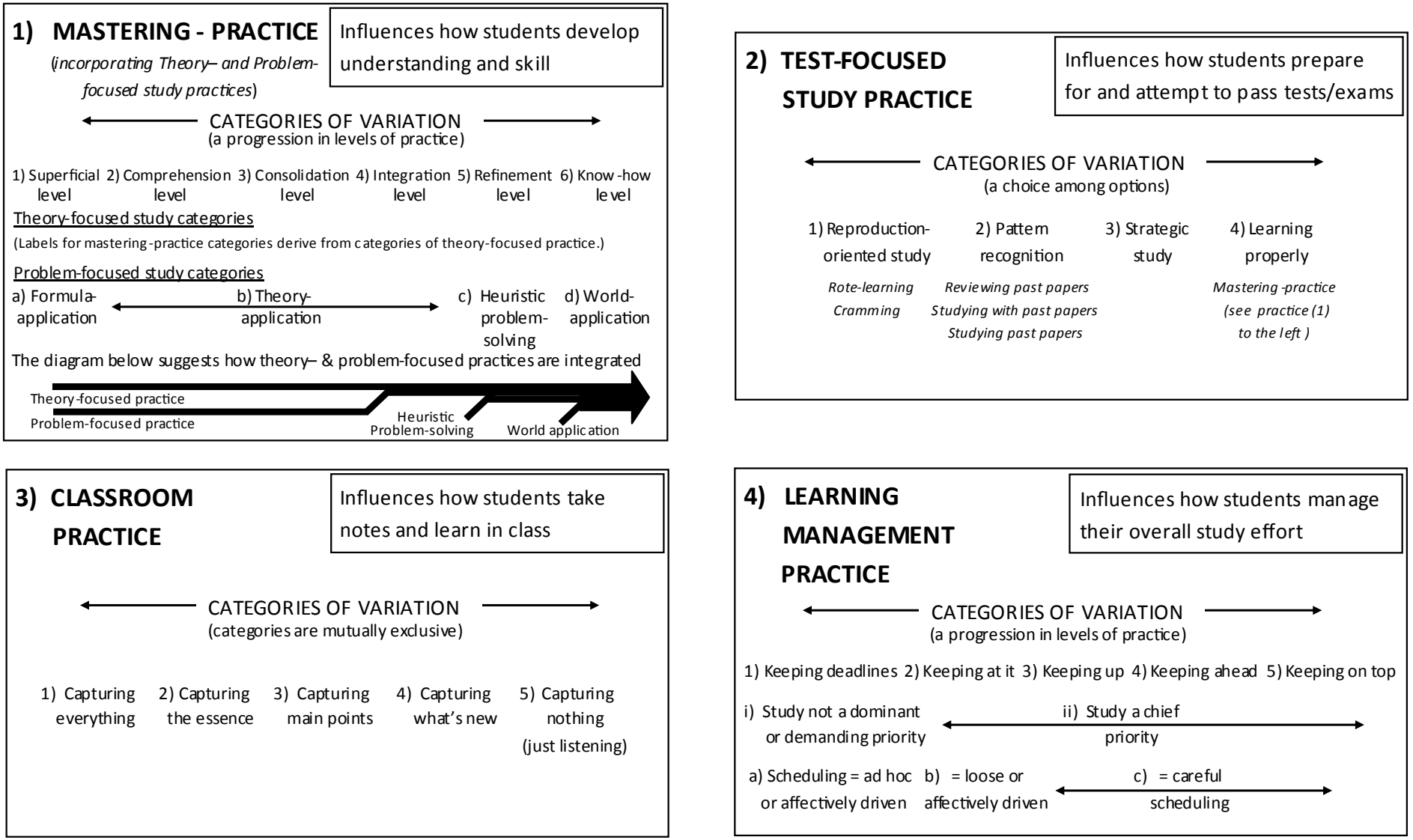


Figure 11.1: The Overall Outcome Space from the Phenomenographic Study: The Categories of Variation of Different Types of Learning Practices