The use of inventories in student learning research: A case study

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Declaration:

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

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ABSTRACT

This study examines the practical use of student learning inventories in the higher education setting, using Vermunt's (1998) Inventory of Learning Styles in the context of a second year Business Statistics course at the University of Cape Town. The theoretical underpinnings of the inventory, as well as its predictive value, are investigated. This is done through the use of simple, yet effective, statistical techniques, some of which have not yet been attempted on an inventory of this kind.

Data were collected through an online course website and student responses to the inventory were analysed along with their final results for the course in question. Quantitative analyses such as the classification of students according to significant score differences, the conduction of a factor analysis, the examination of individual question statistics, the calculation of between-question correlations, the conduction of t-tests for differences in student marks and the calculation of correlations were all completed and are critically assessed.

The final results seem to suggest that the assumptions and theoretical constructs underlying the Inventory of Learning Styles are potentially problematic, in the context of a scientific course, such as the Business Statistics course in question. Also, the predictive nature of the inventory, in terms of predicting individual students' chances of success in the course, is limited. However, the value of the inventory and the study in particular is shown to be in the claims that can be made about the course in general rather than about students' individual learning habits. The value of the use of simple, yet effective, statistical techniques in the analysis of data from inventories such as the Inventory of Learning Styles is also emphasized.

CONTENTS

CHAPTER 1

Introduction

Interest in student learning and ways of measuring student learning has increased dramatically in recent years (Entwistle & McCune, 2004). Student learning research involves the various aspects and characteristics of how students go about learning, with the aim of increasing not only awareness of student learning but also improving the teaching and learning environment, in particular in the higher education setting. With the rapidly changing face of higher education in South Africa and the ever-increasing student numbers experienced at higher education institutions, research into student learning and factors influencing the success of students in higher education settings is vital (Fraser & Killen, 2005).

Measurement of students' ways of learning has often been accomplished through the use of various inventories or questionnaires, of which there are many. It should be noted at this point that the terms 'inventory' and 'questionnaire' are taken to be synonymous and are used interchangeably in the present study, although the term 'inventory' is used more frequently. Inventories, particularly those associated with research such as inventories of student learning, often include instructions for scoring once the inventory has been completed by study participants. Various 'scores' for certain categories, depending on the nature of the inventory and the nature of the study, can then be calculated using participants' responses to individual questions or a group of questions. It should also be noted here that many inventories are 'self-report' inventories, meaning that participants complete the inventory and responses are taken as being correct, with no 'actual' or 'real' data being collected in terms of, for example, annual income or number of hours spent studying a particular subject. Vermetten et al (1999b) mention the major disadvantage of the use of self-report inventories in that "neither actual learning behaviour nor actual descriptions of context are assessed directly, but instead only the students' ideas about it" (p229). They go on to mention that, "although this kind of measurement is common practice in educational research, it is important to acknowledge its limitations." Severiens et al (2001) on the other hand mention the advantage of self-report inventories being the "relative ease of administering questionnaires to large samples of students, and the possibilities for generalising results" (p443).

Some well known inventories such as Entwistle and Ramsden's (1983) Approaches to Studying Inventory (ASI) and Bigg's (1987) Study Processes Questionnaire (SPQ) have been around for some time already and have been 'tested' in a variety of different contexts. Other less well known and more recent inventories have not yet been used in many different contexts, a process vital to establishing validity and reliability.

This project attempts to establish the usefulness and predictive value of one such inventory, Vermunt's (1998) Inventory of Learning Styles (ILS). This is done by various analyses of the responses to the inventory of a group of second year Business Statistics students at the University of Cape Town (UCT) in Cape Town, South Africa. The project is therefore primarily a case study of the use of one particular inventory in a previously 'untested' context. An attempt is made, through the use of factor analysis, to establish whether factors previously identified by other authors as being present in the inventory are present in this context, as well as to determine the value of the inventory in predicting student success in one particular Business Statistics course. Suitable statistical methods for analysing data from such inventories are explored, after highlighting briefly the shortcomings of some of the methods previously employed when analysing data obtained from inventories.

1.1 The rationale behind the present study

As mentioned already, a dramatic increase in the study of student learning has been taking place in recent times. Perhaps one of the greatest 'confusions' in student learning research at the moment is the variety of terminology covering, seemingly, exactly the same concept (Entwistle & McCune, 2004). Student 'ways' of going about learning are discussed as student *approaches to learning*, *learning styles* and *learning orientations*. Vermunt and Minnaert (2003, p. 52), in an attempt to "encompass the different views on the nature and conceptual status of learning styles, learning orientations and learning approaches" (p52) use the term *learning patterns*. It is important to establish right from the start which 'version' of the terminology will be adhered to in the present study. For the purposes of this study, the term 'learning patterns' will be adopted in order to provide an overall term for describing students' ways of going about their learning, as suggested by Vermunt and Minnaert. The debate surrounding terminology is explored in more depth in Chapter 2.

Maxwell (1996) mentions the value in identifying three different purposes in conducting one's research. These include personal, practical and research purposes. The personal purposes for

the present study in this case arise out of my own interest as a lecturer for the second year Business Statistics course at the University of Cape Town. I am firstly interested in what learning patterns students are adopting and, secondly, whether certain learning patterns lead to greater success rates than do other learning patterns, in terms of passing the course.

From a practical point of view, I am interested in whether student learning patterns, as identified by an inventory, are a predictor of success for the course and whether inventories of student learning therefore have some practical use in predicting which students are more or less likely to succeed in the course. Should a relationship between learning pattern and academic success be detected, it could be helpful from a teaching perspective to identify at the beginning of a course which students adopt which types of learning patterns, and to investigate the incorporation of various interventions into the course to help those students who are identified as being at risk of failing. Any research that helps in the teaching of statistics is bound to be of value, as this is a subject which is traditionally found to be very challenging for many students and is a requirement for a wide range of degrees.

In terms of the research purposes of the present study, many inventories that claim to measure student learning have been developed since the 1970's (Biggs, 1993; Cassidy, 2004; Entwistle & McCune, 2004), a fact that makes choosing an appropriate inventory to suit one's own situation a difficult task. Analyses of the data gathered from these inventories have been conducted in various ways, and sometimes the statistical methods employed are conceptually flawed and the resulting interpretations can be both meaningless and invalid (Mitchell, 1997). Using my background in statistics, I therefore hope to identify some of the errors made in the analyses of data, particularly from the inventory chosen for use here, and to find alternative techniques for analysing such data. These findings should have applicability not only to the inventory in use in particular, but also to inventories of student learning in general. From a research point of view, the 'testing' of a particular inventory in a context other than where it has been used before is always valuable.

1.2 The primary research questions

In summary then, the primary research questions to be explored in this study are:

a) Do the learning patterns associated with the Inventory of Learning Styles appear in an analysis of the inventory responses of a sample of second year UCT Business Statistics students?

b) Does the inventory have any predictive value in terms of identifying students who are more likely to succeed in the course, based on what learning patterns are identified?

The first research question therefore relates to what can be termed the *construct validity* of the inventory in terms of its ability to measure what it sets out to measure (Robson, 1993), in this case the learning patterns of the students in the Business Statistics course. The second research question examines what Robson (1993) refers to as the *predictive criterion validity* of the inventory, assessing the way in which student responses to the inventory have any relationship with some other measure, in this case the students' final marks for the Business Statistics course. Any reference to the general validity of the inventory in the present study will therefore be referring to both the construct and predictive criterion validity, as described above.

Both of the questions above required the development of correct and defensible statistical techniques in terms of analysing student responses to the inventory. These methodological issues will be addressed throughout the study and therefore form an additional area to be explored, although not one of the research 'questions' as such.

The present study is therefore primarily a case study on the use of inventories for the determination of student learning patterns in one particular course at one particular university.

1.3 Overview

The thesis sets out in Chapter 2 the conceptual framework used in this study. This is developed by giving a brief history of research into student learning, as well as a background into the debate on various terminologies in use in educational research, a comparison of a small number of key inventories and a description of the inventory chosen for this project, namely the Inventory of Learning Styles (Vermunt, 1998). Chapter 3 includes a review of empirical studies and literature involving the inventory in question. Chapter 4 follows with a description of the research design employed. This includes the basic design of the study and data collection methods, an argument for the use of a case study in this particular project, an overview of ethical concerns arising from the project and a discussion of the form of data analysis used. The results obtained from the student responses to the ILS as well as students' academic performance as measured by their marks for the course are presented in Chapter 5 and a discussion of these results then follows in Chapter 6. Concluding remarks summarising the

most important components of the thesis and the results, as well as a discussion on the implications for future practice, are discussed in Chapter 7.

CHAPTER 2

The Theory of Student Learning

This chapter seeks to explore and discuss the conceptual framework underpinning student learning and the use of inventories in general, as well as Vermunt's (1998) Inventory of Learning Styles in particular. A brief history of the research into student learning is given, followed by an explanation of the range of terminology involved in discussions surrounding student learning. Three different inventories are then discussed and compared, and reasons for the selection of Vermunt's ILS for the present study are explained. Finally, a thorough description of the ILS is given.

2.1 A brief history of research into student learning

Interest in student learning is a relatively 'young' field with initial research and ways of describing student learning surfacing in the USA in the late 1960's and in Britain in the early 1970's. This research signalled a change in direction from ways of measuring attitude and various personality-related variables earlier on in the century (Entwistle & McCune, 2004). Perhaps the most frequently quoted research is that of Marton and Säljö (1976) who, after conducting an experiment asking students to read a certain academic text and then be ready to answer questions about the piece, described what were later termed two "approaches to learning", namely a "deep" approach and a "surface" approach.

Following on from these early beginnings, various other researchers began exploring concepts of student learning and developing inventories which sought to measure different ways in which students learnt. Most notably, Entwistle and Ramsden in 1983 produced the *Approaches to Studying Inventory (ASI)* and Biggs in 1987 developed the *Study Processes Questionnaire (SPQ)*. Both inventories included deep and surface approaches to learning, with a recognisable focus on motivation and strategy, aspects included in other inventories developed during the 1980's and 1990's (Entwistle & McCune, 2004).

Webb (1997) and Haggis (2003) provide some critique of the current research into student approaches to learning and, in particular, of the notion of "deep" and "surface" approaches. Webb, in particular, argues that the notion of a deep approach to learning has come to be seen as superior to a surface approach and yet surface approaches to learning are appropriate in

certain circumstances. He also argues that it is surprising that a "lack of contest and criticism" has existed about the deep/surface model "over such a long period" (p199). Entwistle (1997) responds to this argument by saying that the deep/surface model still has value in the sense that it depicts a "recognizable reality" with great value being in the "strength and simplicity" of the model, which has been proved numerous times with empirical evidence (p214 and 215). Haggis (2003) argues that the deep/surface model makes numerous assumptions about the purposes and motivation of students in their learning, such as the assumption that students' purposes and motivations for learning can be made to mirror those of academics and the institution. She also argues that the model ignores the individual, personal context of the student, something which is a vital part of learning and study success. Marshall and Case (2005) respond by agreeing with Haggis that certain ideas surrounding the theory need to be reviewed and strengthened, particularly in terms of conceptual notions and the debate surrounding approaches to learning and learning styles (see below), but they suggest that "rather than discarding the theory altogether", differing opinions and contributions towards the model "have the potential to enrich and extend it, and in doing so, address some of the valid critiques levelled against it" (p265).

2.2 The debate surrounding learning approaches, learning styles and learning orientations

Undertaking research in student learning necessitates the reading of various theories, empirical findings and conceptual ideas. One would be forgiven for thinking that the different researchers in the field had never consulted one another, as the range of terms used for seemingly the same concept is astounding. As Entwistle and McCune (2004) mention,

> "One of the main problems in reading this literature on study strategies for the first time is the different meanings given to the same term, and the existence of different terms apparently covering the same aspect of studying." (p339)

The current debate revolves around whether student *ways* of going about learning should be referred to as *approaches to learning* or *learning styles*. Biggs (1993) argues that learning styles and approaches to learning are fundamentally different in the sense that "learning styles refer to structure, not to process" (p5), and the fact that learning styles ignore the context in which learning is taking place and are seen as a "non-negotiable" aspect of the learning experience. He argues that approaches to learning include both the motivation and attitudes

towards learning experienced by the student and are thus less rigid than learning styles. Cassidy (2004) refers only to learning styles and not to approaches but does mention the "state-or-trait debate" (p421) and concludes that learning styles do have a component of stability over time (the trait) as well as the ability to change given the context (the state). Learning *orientations* (referred to by Gibbs et al (1984)) are also referred to when talking about student learning, although not as frequently as learning approaches or styles. Lonka et al (2004) see learning orientations as being similar to learning styles - a term which they describe as "problematic" (p305) - in the sense that they describe a student's natural inclination towards a certain way of learning. They also note that learning approaches "may be seen as less stable than orientations or styles" (p304). As mentioned earlier, the more recent term *learning patterns* has been proposed by Vermunt (Vermunt and Minnaert 2003, Vermunt 2005) in order to bring together the concepts of learning approaches, styles and orientations. It is hoped that some clarity and consensus on the use of terminology is reached between researchers in the near future, a point also made by Entwistle and McCune (2004). It is also for this reason that Vermunt's use of the term learning *patterns* is favoured in the present study, as it is not an attempt to create yet another 'word' for something already out there but rather an attempt to synthesize the assumptions, some explicit and some implicit, made by the various other 'competing' terminologies.

2.3 A comparison of available inventories

The increasing interest in the research of student learning has meant that a large variety of inventories have been developed and are in use, making it a sometimes mind-boggling task trying to choose an appropriate one to use to suit one's purpose, especially as many have been "developed for rather different purposes, derived from contrasting theoretical perspectives, and labelled in different ways" (Entwistle and McCune 2004, p326). Biggs (1993) goes so far as to mention that there are "too many scales to be useful" (p4). However, no inventory on student learning is useful unless it provides useful data and information for teachers (Biggs, 1993) and therefore choosing even one inventory and assessing its 'usefulness' in one's own situation is, I believe, a valid exercise.

Entwistle and McCune (2004) provide a comparison of six commonly used inventories, namely Entwistle and Ramsden's (1983) Approaches to Studying Inventory (ASI), Bigg's (1987) Study Processes Questionnaire (SPQ), Vermunt's (1998) Inventory of Learning Styles (ILS), Schmeck et al's (1991) Revised Inventory of Learning Processes (ILP-R), Weinstein et al's (1987)

Learning and Study Strategies Inventory (LASSI) and, finally, Pintrich et al's (1991) Motivated Strategies for Learning Questionnaire (MSLQ). Cassidy (2004) also provides a more comprehensive comparison of a larger number of inventories listing where they come from, what they comprise and how they are used, however, for the purposes of this research, the only the 'main' inventories identified by Entwistle and McCune will be identified and discussed.

Entwistle and McCune's (2004) comparison of the six inventories mentioned above includes descriptions of areas or scales in the inventories which have been specifically 'named'. For example, the "meaning orientation" of the ASI or the "achieving approach" of the SPQ have been specifically called by these terms, whereas the apparent deep approach of the MSLQ has not been termed a "deep approach" as such. The six inventories are all scored by adding respondents' scores for particular questions, but only three of the six inventories, namely the ASI, the SPQ and the ILS, result in 'scale scores'. In choosing an inventory to use in the current study, these three options were considered. The three inventories specifically identify learning approaches, orientations or styles once the inventories have been completed by students, making them 'easier' to score and interpret, as opposed to the inventories such as the LASSI, MSLQ and ILP-R mentioned above in which the scales are not specifically identified.

The ASI and SPQ are acknowledged by Entwistle and McCune to be based on the same conceptual backgrounds and both inventories identify three main approaches to studying. The ASI refers to these approaches as orientations and identifies the meaning, reproducing and achieving orientations, as well as a non-academic orientation. The first three orientations map directly onto the approaches identified by the SPQ, namely the deep, surface and achieving approach. Schmeck's Revised Inventory of Learning Processes (ILP-R) also identifies four approaches to student learning which can be seen to be analogous with the deep, surface, achieving and non-academic approaches identified by the ASI and SPQ, although these approaches are not specifically identified or 'scored' as such in the inventory. Entwistle and McCune mention the difficulty in finding similarities between the ILP-R and other available inventories in terms of some of the items in the ILP-R which do not match with equivalent question items or scales in other inventories. Weinstein et al.'s Learning and Study Strategies Inventory (LASSI) also fits the ASI and SPQ framework, although, once again, the approaches are not specifically termed, as such, in the inventory. Vermunt's Inventory of Learning Styles (ILS) and Pintrich et al.'s Motivated Strategies for Learning Questionnaire (MSLQ) specifically and explicitly include aspects of students' monitoring and regulation of their learning (Entwistle

and McCune, 2004). The scales of the MSLQ, although not identified specifically, do coincide once again with the deep, surface and achieving approaches of the ASI and SPQ, as well as the undirected approach. Vermunt's ILS is slightly different from the other inventories reviewed in that it identifies a type of learning not identified by other inventories, namely that of application-directed learning, which is explained in detail in Section 2.4 below. Vermunt specifically identifies three other learning patterns arising from the inventory: the meaning-directed pattern which maps onto the deep approach to learning from the ASI and SPQ, the reproduction-directed pattern which maps to the surface approach and the undirected pattern which maps to the non-academic orientation of the ASI. Although none of the patterns maps specifically to the achieving approach identified by the ASI and SPQ, self-regulation of learning is identified by the inventory as falling under the meaning-directed learning pattern.

Although the ASI and SPQ are among the first of the inventories developed and have been widely used, it is Vermunt's Inventory of Learning Styles (ILS) that has been chosen for use in the present study for a number of reasons. Firstly, as mentioned above, the ILS identifies the application-directed learning pattern which is not like any other learning pattern identified by other inventories. In the case under review here, that of a group of students in a second year Business Statistics course, it is hypothesised (see later) that a large number of students may indeed exhibit an application-directed learning pattern and being able to pick this up through the use of the ILS could prove to be useful. A second reason for using the ILS is that although it is long (the revised version consists of 100 items), this makes it appear to be very thorough and potentially more likely to pick up on actual 'patterns' than, for example, the shorter RASI, the revised version of the ASI. Thirdly, the ILS not only identifies four learning patterns but also identifies other 'subscales', that is, three learning processing strategies, three regulation strategies, five different conceptions of learning and five learning orientations. These are described in the following section, but in terms of choosing an inventory, the ability to not only identify a student's particular learning pattern, as according to the inventory, but also, for example, their conception of learning, was seen as having value in its own right. A fourth reason for choosing the ILS is the fact that it has not been used much outside of the European context, unlike the ASI and SPQ. Being able to use and 'validate' an inventory in a context which is, at many turns, completely different to the European one is bound to add value to literature surrounding the use of the inventory and, hopefully, to the field in general. Finally, the wording of the statements in the ILS seemed more accessible to South African students and indeed to our specific disciplinary context than the other inventories described. For example, a statement

such as "I prefer a type of instruction in which I am told exactly what I need to know for an exam" (Vermunt, 1994a) used to ring true for myself as a student and is bound to 'make sense' for many students in the course under study. It may also be true that the translation of the original inventory from Dutch into English has meant that the language and the wording of the question statements has remained simpler.

The following section describes the ILS in more detail, as well as mentioning various advantages and disadvantages associated with its use.

2.4 Vermunt's Inventory of Learning Styles

The Inventory of Learning Styles identifies four learning patterns based on students' learning characteristics in four different areas or domains, which Vermunt (2005) terms "components". These four components are the processing strategies, regulation strategies, conceptions of learning and learning orientations. Vermunt and Vermetten (2004) provide helpful explanations of the four areas.

Processing strategies are the various ways students go about understanding and 'processing' the material being studied. According to the ILS, three different processing strategies are usually identifiable – deep processing, stepwise processing or concrete processing strategies. Students adopting deep processing strategies will make connections between subjects to form an overall 'big picture' of their learning and will also generally make their own conclusions and deductions about something and be critical of the conclusions made by others, rather than simply accepting them. Students adopting stepwise processing strategies will rote learn and memorise material as well as analyse bit-by-bit every detail of the material they are studying until they are sure that they have understood or at least learnt to heart all the definitions, assumptions and characteristics, for example, of what they are learning. Those adopting concrete processing strategies will learn the material they are studying by applying it through concrete experience and examples.

Regulation strategies involve the way and extent to which students go about planning and monitoring their learning and testing their knowledge (or lack thereof) of a particular subject. Self regulation, external regulation, and lack of regulation are identified by Vermunt in the ILS as being the possible regulation strategies. Students adopting self regulation strategies will monitor their own learning and plan their studying, as well as adding to the material they have for

learning by consulting outside sources such as television, other books and the internet, for example. Those adopting external regulation strategies will rely on instructions provided by others, such as teachers, as to how to go about their learning, and will consult sources such as past test or examination papers as sources for their learning. Students experiencing a lack of regulation will realise that their own study methods are failing but have difficulty in attempting to regulate and organise their learning effectively.

The third component of learning, *conceptions of learning*, is the student's idea about why learning and knowledge are seen as important and include learning as the construction of knowledge, learning as the intake of knowledge, learning as the use of knowledge, learning as stimulating education, and learning as being co-operative. Students who see learning as the construction of knowledge view the learning process as the forming of one's own opinions and realise that the responsibility of learning lies with the student. Those who see learning as the intake of knowledge view the learning process as the taking in of knowledge provided by other sources, such as teachers, and, as such, learning within the student is the responsibility of the teacher. Learning seen as the intake of knowledge relates to learning in which practical experience is possible and is both the responsibility of the teacher and the student. Learning seen as stimulating education is when the responsibility of making learning interesting and stimulating is seen as lying with teachers. A co-operative conception of learning is when learning is seen as most valuable and effective when done with others.

Finally, in terms of the four components of learning in the ILS, *learning orientations* refer to the reasons why students study and learn, and their motivation for learning. These include a personally interested orientation, a certificate orientated orientation, a self-test orientation, a vocation orientated orientation and an ambivalent orientation. Students who are personally interested in their learning study out of interest in the subject and for personal gain. Those who are certificate orientated in their learning study to obtain a degree, certificate or some other qualification, or even just to pass an examination. Those who are self-test orientated in their learning study in order to prove to themselves and others that they are able to undertake studies (in higher education) and succeed at these studies. Students with a vocation directed learning orientation study above all to acquire the qualifications and skills necessary for a particular profession, whilst those with an ambivalent learning orientation are unsure and uncertain towards their studies, their own abilities to study and their choice of discipline.

Vermunt (1998) proposes that the four components of learning as mentioned above are interrelated in that the conceptions of learning and learning orientations that students have in turn affect their learning regulation strategies, which consequently affect their processing strategies.

The 100 item version of the ILS (as opposed to the original 120 item version) has 25 items for each of the above four domains – processing strategies, regulation strategies, conceptions of learning and orientations of learning. Part A of the inventory has items or statements concerning students' "study activities", or rather processing and regulation strategies. Students are asked to rate a statement on a scale of 1 to 5 where 1 corresponds to "I do this seldom or never" and 5 corresponds to "I do this almost always". Part B of the inventory has items relating to "study motives and views on studying" and therefore concerns the conceptions of learning and learning orientations that a student has. Students rate statements on a scale of 1 ("Disagree entirely") to 5 ("Agree entirely") (Vermunt, 1994b).

Appendix C provides a summary of the relationship between the four components of learning and the learning patterns identified by the ILS. The four different learning patterns as identified by the inventory are the *meaning-directed* learning pattern, the *reproduction-directed* learning pattern, the *application-directed* learning pattern and the *undirected* learning pattern. The implicit assumption of the inventory is that individual students will adopt or exhibit primarily one of the four learning patterns. In terms of the processing strategies, regulation strategies, conceptions of learning and learning orientations mentioned above, students with a meaning-directed learning pattern are more likely to employ deep processing strategies in their learning, be self-regulated in their learning, view learning as the construction of knowledge and be personally interested in their learning. Students with a reproduction-directed learning pattern are likely to process knowledge in a stepwise fashion through memorising and rehearsing, to rely on external regulation of learning, to view learning as the intake of knowledge and to be both certificate-orientated and self-test orientated in their learning. Students who exhibit application-directed learning patterns show concrete processing strategies, in other words learning and understanding through concretely applying knowledge. They are also likely to view knowledge as something that can be practically 'used' or applied and are vocation-orientated in their learning. Students with an undirected learning pattern exhibit lack of regulation when it comes to learning and see learning as being something that should be made to be stimulating and interesting by those conveying the subject material and something to preferably be learnt in

a group setting rather than as an individual. Students with an undirected learning pattern are also ambivalent about their learning orientation and are often not entirely sure as to why they are learning what they are learning.

The advantages and disadvantages associated with the ILS need to be considered before it is used. The length of the inventory is one of its disadvantages and, as Entwistle and McCune (2004) mention, "The longer the inventory, the less care students take in completing it, and the less likely are staff to use it" (p340). However, studies which have previously used the 100-item version of the ILS have noted that the time taken to complete the inventory is typically between 20 and 25 minutes (Boyle, Duffy, & Dunleavy, 2003) which is, I believe, not an unreasonable time commitment. This was mentioned to students before they completed the questionnaire, and as students were under no obligation to participate in the study, it is hoped that those that did respond would have done so with a reasonable amount of care. Entwistle and McCune mention the major drawback of the ILS being the fact that it lacks the inclusion of items which explicitly question the motivational and effort aspect of studying and learning, and thus exclude the 'achieving' approach to learning as included in the ASI and SPQ. However, they do concede, as previously mentioned, that the identification of the application-directed learning pattern is a possibly very valuable addition as it suggests a "more practical way of thinking" (p340). They also mention the importance of items relating to collaborative studying amongst students, something which has become increasingly important in higher education in recent times yet is still left out of the majority of other inventories. A further criticism levelled against the ILS is its lack of application for students in their later years of study. As Busato et al (1998) mention, "No explicit questions are asked about, for example, doing literature research, writing a thesis or doing empirical research" (p438). However, since the research being undertaken in the present study involves students in their second year of study, this concern is not of importance here, although it can be noted as a general concern relating to the use of the ILS.

The following chapter offers a review of some of the studies undertaken which make use of Vermunt's Inventory of Learning Styles.

CHAPTER 3

A Review of Studies Using the Inventory of Learning Styles

The purpose of the literature review for the present study is to demonstrate the broader literature that forms a backdrop to the research questions proposed In Chapter 1. Therefore, the literature review undertaken here will take the form of a review of empirical studies that have been conducted using Vermunt's ILS. The conceptual underpinnings of this inventory, and of student learning research in general, have been discussed in Chapter 2. This chapter will start by reviewing studies which have made use of the ILS and will then bring together the issues that arise out of these studies which make the present study relevant.

Busato et al (1998) provide one of the earliest examples of studies making use of the ILS. Using psychology students from the University of Amsterdam in the Netherlands, they conducted both a cross-sectional study, across students in different years at the same point in time, and a longitudinal study, of various cohorts of students as they progressed through years of study, in order to determine whether student learning patterns differed according to year of study. In the cross-sectional study, no evidence was found to indicate that students in their later years of study were more likely to exhibit meaning-directed or application-directed learning patterns. In the longitudinal study, slightly significant results showed that students' scores for the meaning-directed learning pattern increased marginally in their later years of study. It was also found that a negative correlation occurred between academic success and an undirected learning pattern.

A second study conducted by Busato et al (1999) uses the results from the ILS as answered by 1072 psychology students at the University of Amsterdam (not the same group of students as in the 1998 study mentioned above) and examines the relationship between learning patterns, as measured by the ILS, and personality traits and achievement motivation, as measured by two other inventories. It was found that learning patterns did correlate with the "Big Five" personality traits as measured by the 5PFT ("Vijf Persoonlijkheids-factoren Test") inventory, although the correlations in most cases were very small (mostly around 0.15). Learning patterns also correlated with achievement motivation as measured by the PMT ("prestatie-motivatie-test") inventory, although once again these correlations are small.

Lindblom-Ylänne and Lonka (1999) constructed an inventory using certain sections of the ILS as well as sections of the ASI and statements constructed by the authors. Using this inventory they tested the relationship between learning patterns, as identified by four "clusters", and academic success in advanced medical and psychology students in Finland. Cluster analysis allowed the separation of students into groups or clusters. The results showed that students adopting meaning-directed learning patterns achieved the highest results and those adopting reproduction directed learning patterns achieved the lowest results. It should, however, be noted that these results are not necessarily comparable to other studies since the various inventories that were combined are based on slightly different conceptual frameworks.

Slaats et al (1999) use a revised version of the ILS, specifically designed for students in vocational training in the Netherlands (the ILS for secondary vocational education, ILS-SVE). 1036 students completed the ILS-SVE, and a factor analysis revealed slightly different learning components to those identified by the original ILS. Whereas Vermunt identified 16 different scales on which the ILS was based, Slaats et al's study identified 10. The lack of regulation, stimulating education and co-operative conceptions of learning, self-test directed and ambivalent learning orientations did not appear to be present. Also, the certificate driven and vocation driven learning orientations could be combined into one scale, that which Slaats et al termed an "extrinsic" learning orientation. A prevalence of one type of learning pattern was found for each of four vocational disciplines – commercial, technical, health and agriculture. The authors question whether it is "the context of a certain discipline that affects students' learning styles" or whether "students with particular learning styles are choosing particular disciplines" (p490). They mention that it might be a combination of the two in the sense that part of the way a student learns is because of who s/he is as a person and, on the other hand, due to the context s/he finds him or herself in. This is what Cassidy (2004) refers to in his mention of the "state-or-trait debate" (see Chapter 2, Section 2.2). An interesting finding in this study is the fact that commerce students had primarily reproduction-directed learning patterns. As most of the students in the second year statistics course in the current study are from a commerce background, it will be interesting to see whether the same result holds true in this case.

Vermetten et al conducted two studies making use of the ILS in 1999. The first (1999a) examined how student learning patterns are sensitive to context, and involved students from four different courses within the law programme at a Dutch university completing Part A of the

ILS, which deals with processing and regulation strategies. The results showed differences in learning strategies within the same group of students across different contexts, although at the same time, individual consistency of learning strategies in students were also found across different contexts. Some processing and regulation strategies, such as concrete processing and lack of regulation, showed variability depending on context, whereas stepwise processing strategies such as memorisation showed little variability across context. These results are interesting given Slaats et al's hypothesis mentioned above, and Cassidy's (2004) "state-or-trait debate" mentioned in Chapter 2, that student learning patterns are partly due to personality factors but also due to context.

The second study conducted by Vermetten and colleagues which was published in 1999 (Vermetten et al, 1999b) used longitudinal data collected from 276 economics, law, arts and social science students at Tilburg University in the Netherlands. Results from the ILS were collected and compared after the first and third semesters of study, that is, after six and eighteen months of study. Results showed the factor structure of the ILS after the third semester of study to be more in agreement with the factor structure initially identified by Vermunt, and the mean score for meaning-directed learning patterns to be higher.

Severiens et al (2001) also used only the statements relating to the regulation and processing strategies within the ILS (similar to Vermetten et al (1999a)) in order to determine whether a change over time (between three and six months) in learning strategies were observed in 191 adult secondary education students and 271 technical college students from various institutions in the Netherlands. Overall, a change in learning strategies was detected, notably a decrease in stepwise processing strategies and in external regulation strategies.

Boyle et al (2003) conducted a study to determine the validity of the ILS in the British higher educational context using 273 social science students from a British university. The inventory was found to be valid, especially in terms of a factor analysis which confirmed the four factors in the ILS as found by Vermunt originally. The relationship between learning pattern and academic success was investigated and significant positive relationships were found between the meaning-directed learning pattern and academic success, and negative relationships between the undirected learning pattern and success.

Veenman et al (2003) examined the correlations between learning pattern as measured by the ILS and academic success of 1060 students at the Technical University of Delft in the Netherlands and found that the ILS was a weak predictor of academic success. Students in the study came from various departments at the university including Applied Physics, Architecture, Computer Science, Electro-technology, Engineering, Industrial Design, Technical Mathematics and Technological Management. One of the aims of the study was to determine whether students "at risk" of failing could be identified ahead of time. A second part of the same study involved interviewing 33 students who completed the ILS in a 'think-aloud' task, that is, asking students to complete a particular academic task and to voice aloud all their thoughts whilst completing the task. The study processes involved in these think-aloud tasks were then analysed and categorised. An interesting result was the lack of correspondence between what students reported as their study habits on the ILS and what they actually did on the think-aloud exercise. The authors conclude that the use of self-report instruments should therefore be reconsidered and that "it should be acknowledged, conclusively, that the ILS is not an appropriate instrument for identifying students at risk" (p362).

Vermunt and Minnaert (2003) looked at dissonance in the learning patterns of 244 social science students at a Dutch university, where dissonance was defined as being "the absences of linkages among learning conceptions, orientations and strategies that theoretically should be there, or as the presence of relationships among these learning components that theoretically should not be there" (p51). Students completed the ILS after their first and again after their third semester of study and results indicated a significantly weaker factor structure after the third semester, with the meaning-directed learning pattern still being significant, although not as much as after the first semester. A dissonant second factor was identified which did not fit the theory, whereas after the first semester this had been a clear reproduction-directed pattern. The third factor was also dissonant although could have been a combination of the undirected and reproduction-directed learning patterns. A fourth factor was not evident in the factor analysis after the third semester of study. These results, interestingly, directly contradict those found by the Vermetten et al (1999b) study. The authors question whether the theory should be revised or whether real dissonance is evident when a situation as the one described here occurs and conclude that should the dissonance be a 'real' phenomenon then theory should indeed be revised.

The final study on the use of the ILS to be reviewed here is one conducted by Vermunt himself (Vermunt, 2005) in which the relationship between learning pattern and various personal and contextual factors and academic success was investigated. Dutch students from a variety of disciplines completed the ILS. The different disciplines included Law, Management Information Science, Economics, Sociology, Psychology and Arts. Personal variables such as gender showed no relationship with learning pattern although age showed a slight relationship with the meaning-directed learning pattern. Prior education was found to be a predictor of the reproduction-directed learning pattern and academic discipline was shown to be a very significant predictor of learning pattern, an interesting result and confirming the results of Slaats et al (1999) study. Significant correlations were found between learning pattern and academic success with meaning-directed learning patterns being generally positively correlated with academic success and reproduction-directed and undirected learning patterns having negative correlations with academic success.

We turn now to the issues arising out of the studies reviewed above, indicating how these are relevant to the present study.

3.1 Assumptions underlying studies using the ILS

The studies reviewed above often include the results of various statistical tests. Tests such as the t-test to compare means were conducted by Busato et al (1998), Vermetten et al (1999b), and Severiens et al (2001). Analyses of Variance, or ANOVA, tests were conducted by Busato et al (1998), and Vermetten et al (1999a), and multiple regressions were performed by Boyle et al (2003) and Vermunt (2005). All of the tests mentioned above require the data to follow a normal distribution, and it is unclear in all of the studies whether this assumption was met or not. This is a point made by Mitchell (1997) concerning many similar studies in educational research which obtain results using statistical techniques, often in error, on data gathered from inventories.

Another critique made by Mitchell, which applies to all of the eleven studies reviewed above, is the fact that variables on an *ordinal scale*, where students have to rank statements according to how much they agree with what is being said, have been turned into variables on an *interval scale* where the difference between a score of 3 and 2, for example, is exactly the same as the difference between a score of 5 and 4. Calculations of the mean scores for these variables are therefore meaningless because if a score of 2 corresponds to "somewhat agree" and a score of

3 corresponds to "uncertain", then an average score of 2.45, say, would be very difficult to interpret. The above studies therefore all make the implicit assumption that the variables on an ordinal scale can reasonably be 'converted' into variables on an interval scale. This assumption is not mentioned in any of the studies reviewed and applies particularly to studies in which mean scores for learning components and/or learning patterns were calculated, such as the Slaats et al (1999) study and the Vermetten et al (1999a), Vermetten et al (1999b) and Severiens et al (2001) studies.

The calculation of correlations between scores on an inventory and academic results also require the assumption that the scale scores fall on an interval scale. The Busato et al (1999), Veenman et al (2003) and Vermunt (2005) studies all compute correlations without stating whether or not this assumption is being made. Furthermore, the calculation of correlations between categorical variables such as academic discipline and variables on an interval scale, such as age, cannot reasonably be computed, as has been done in the Vermunt (2005) study.

Given the various statistical errors, or rather 'slippages', made in the studies mentioned above, a thorough, correct statistical analysis of data from the ILS, in any context, can only be a valuable contribution to the current literature.

3.2 Investigating the factor structure of the ILS

In order to use an inventory such as the ILS, one first needs to determine whether the theoretical constructs underlying the inventory apply to the context in question. This can be done through the conduction of a simple factor analysis or through the more complicated method of principal components analysis.

Four of the eleven studies reviewed above did not involve any 'confirmation' of the theory underlying the ILS by conducting a factor analysis or principal components analysis. These were the Busato et al (1998), Busato et al (1999), Vermetten et al (1999a) and Severiens et al (2001) studies. This can be problematic in the sense that, for example, Busato et al (1998 and 1999) simply add the corresponding learning component scale scores to obtain an overall pattern score for students, for example, a score for the meaning-directed learning pattern. This, firstly, does not say much about the student's individual learning strategies, orientations and conceptions and simply lumps them together in one score and, secondly, no factor analyses are

conducted to determine whether the factors identified by Vermunt (1998) as contributing to each learning pattern are evident in the samples under consideration in the studies.

The remaining studies all conducted either factor analyses or principal component analyses and confirmed the presence of factors as identified originally by Vermunt, although the Vermunt and Minnaert (2003) study, as mentioned above, found "dissonant" study patterns not in accordance with the theory.

It is important to note that a factor analysis also implicitly assumes the presence of interval rather than ordinal data, as factor analyses are based on correlations between variables. In terms of confirming the construct validity of the ILS, as mentioned in Chapter 1, a factor analysis is needed to answer the first of the two research questions posed and is therefore a key aspect of the present study.

3.3 Predictive testing of the ILS

Investigating the relationship between learning patterns and academic success in our specific context is important in order to answer the second research question and determine the predictive criterion validity of the ILS. Also, some of the studies reviewed find conflicting results in this regard. For example, Vermunt (2005) finds significant relationships between learning patterns and academic success whilst Veenman et al (2003) find no such relationships and call for the acknowledgement of the ILS as not being effective in predicting academic success. Busato et al (1998), Lindblom-Ylänne and Lonka (1999) and Boyle et al (2003) also find significant relationships between learning patterns and academic success. In general, positive relationships between the meaning-directed learning pattern and academic success, and negative relationships between the undirected and reproduction-directed learning patterns and academic success, were determined.

In general, studies testing the predictive ability of the ILS have looked at the results of a group of students as a whole, and have not attempted to 'categorise' students individually according to their learning patterns or in terms of the scales of their learning components.

3.4 The context of studies using the ILS

It is interesting to note that all of the studies reviewed involving the use of Vermunt's ILS have been conducted in the European context, with nine of the eleven being conducted in the

Netherlands, Vermunt's home country. As far as can be seen, no studies have yet been done using the ILS in an African context, let alone in South Africa. Also, almost all of the studies reviewed, with the exception of the Veenman et al (2003) study, involve students studying subjects from the field of humanities, such as psychology. These two contextual aspects make the present study, the testing of the instrument in a completely 'new' setting using South African Business Statistics students, an interesting and worthwhile one.

3.5 Interventions resulting from studies using the ILS

Two of the studies reviewed, namely Lindblom-Ylänne and Lonka (1999) and Vermunt and Minnaert (2003) mention specific interventions in students' learning following the studies.

In the Lindblom-Ylänne and Lonka (1999) study the authors make use of the inventory by allowing students to complete and score the inventory themselves and to then read an interpretation of their results and how these are shown to relate to academic success. Students then have the opportunity, if they so wish, to discuss the results from their completion of the inventory, and the possible consequences thereof, with their lecturer. A practical 'result' of the Vermunt and Minnaert (2003) study, as with the Lindblom-Ylänne and Lonka (1999) study, is that students were given feedback upon the completion of the ILS as well as personal study advice as, according to the authors, "many students fail to estimate appropriately their own learning strategies, orientations and conceptions" and that "the feedback provided students with a more objective estimation of their strengths and weaknesses in their learning patterns" (p53). 'Interventions' of this sort following the present study may be worthwhile, particularly if the inventory is indeed found to have predictive value in terms of identifying students at risk.

We turn now to the design of the research project. A brief discussion on case studies as a valid research method for the present study, a description of the data collection methods and a discussion on the ethical issues surrounding the present study are among the topics presented in the following chapter.

CHAPTER 4

The Research Design

This chapter outlines the approach that was taken in designing the present study. The use of a case study as a method for the present study is firstly explored and defended. The inventory used and the context in question are then described, and an account of the data collection methods used is given as well as an idea of the sample obtained. The ethical issues surrounding the present study are also discussed. Finally, the method, in terms of the analyses used to obtain results, is presented.

4.1 Defending the case study

In the realm of scientific research, Flyvbjerg (2001) notes that the case study is often seen as an 'unscientific' research method. He mentions five common misconceptions about the case study as a method of scientific research. These include the fact that theoretical knowledge is often seen as being 'better' than practical, experiential knowledge; the fact that one is unable to generalise on the basis of a case study and therefore case studies do not contribute in any meaningful way to scientific research; that case studies are only useful for generating hypotheses, not testing them or building models; that case studies tend to conform to the researcher's expectations about what might happen in a certain area of research and are therefore biased; and, finally, that general scientific theories are hard to generate based on case studies.

In answer to the above concerns about the case study as a valid research method, Flyvbjerg comments that "in the study of human affairs, there exists only context-dependent knowledge" (p71) and the fact that "knowledge cannot be formally generalised does not mean that it cannot enter into the collective process of knowledge accumulation in a given field on in a society" (p76). He argues that the fact that case studies are so often used to disprove general theories, by showing an example of where a particular theory might not hold, means that they are valid in both the setting up of hypotheses and the testing of these. Also, researchers often set out to 'prove' a certain theory using a particular case and come away with quite the opposite, finding that what they had set out to prove was actually disproved in the case under study. This point seems to nullify the argument that researchers are often biased in their results when making use of a case study as a method of research. On the issue of generalisation of case studies,

Stake (1994) argues that "damage occurs when the commitment to generalize or create theory runs so strong that the researcher's attention is drawn away from features important for understanding the case itself" (p238).

Stake (1994) identifies three different types of case studies. *Intrinsic* case studies are case studies in which the researcher is interested in the particular case itself and not in the proving or disproving of theory. *Instrumental* case studies are those in which the researcher is setting out to gain insight or to confirm or reject a theory and the interest is not primarily in the case itself. The third type of case studies, *collective* case studies, is a group of instrumental case studies, in which the primary focus is to refine theory. The present study is primarily an instrumental case study, as it involves the validation of a particular inventory, and is therefore based on particular theories and concepts. Although it also focuses on one particular group of students in one particular course at one particular university, and the fact that the learning patterns of this particular group of students is of interest in itself, this group is no different as such to any other group of second year Business Statistics students. Therefore, the case is not an unusual one which we are attempting to understand. Although only making use of the responses of one group of students to the inventory in question, the case study still has value in that it will either validate the inventory, by finding four similar factors emerging from student responses, or it will call the validity of the inventory into question by finding different factors or perhaps even no clear factor structure in the inventory. Either result could be considered valuable to the field of higher education, which is where the ILS is primarily used. Also, the fact that no such study on a group of Business Statistics students at the university in question has yet been conducted, makes some knowledge about the way in which these students tend to learn valuable, as it is better than no knowledge at all. This, I believe, is what Flyvbjerg is attempting to say when he mentions that knowledge about something, which cannot be generalised, "does not mean that it cannot enter into the collective process of knowledge accumulation in a given field on in a society" (p76). As Stake (1994) mentions, "The purpose of case study is not to represent the world, but to represent the case" (p245).

When talking about generalisability, Lincoln and Guba (1985) argue that *transferability* is preferable to generalisability in the context of, particularly, social science research. Generalisability refers to the ability to generalise a result from one particular context to a 'new' context, no matter what this new or other context might be and without the specifics of the other context being known. This is, understandably, often difficult, particularly in the case of research

involving human subjects. Transferability, on the other hand, allows for the specifics of the new context to be known and understood and for the results from the "sending" context to be similar to those of the "receiving" context, as defined by Lincoln and Guba (p124). The present study aims more for transferability as opposed to generalisability, because, should the characteristics of another context be similar to the one in question here (that of a service course to primarily Commerce students at second year level in an African university), it is certain that similar results should be found as the ones to be discovered in this research. That being said, for transferability to take place, the onus is on the reader of the study to decide whether his or her particular context is similar to the one being described in the study, and the responsibility of accurately describing the context in which the study takes place rests with the researcher.

Stake and Trumbull (1982) have introduced the concept of *naturalistic generalisation.* This refers to the change of thinking taking place in the reader of a particular case study because of his or her ability to identify with the case in question and to experience the context as though it were his or her own. Knowledge gained in this way, according to Stake and Trumbull, is often more useful than knowledge gained from "most research findings, and the new knowledge produced by large-scale projects" (p2) because the reader, or practitioner in the case of a teacher or administrator, is able to feel empathy with what is happening. Although each context has its idiosyncratic features, there are some issues common to the teaching of Statistics courses at South African universities. For example, large class sizes, the teaching of a 'service' course such as Statistics, the particular assessment methods used and the fact that the study takes place in a South African university as opposed to one overseas, are all factors with which local readers of the research may identify. It is hoped, therefore, that this strengthens the use of a case study as a method of research in the present study.

4.2 The inventory

In order to answer the research questions outlined in Chapter 1, student responses to the ILS were needed as well as some measure of academic success. The Inventory of Learning Styles was voluntarily completed by second year Business Statistics students at UCT through the online course website. Permission to use the inventory in this way was granted by the author in personal communication via email.

Certain statements in the ILS were reworded to suit the context of the course and permission for this was also granted by the author. The adapted version of the ILS is presented in Appendix A

with the scoring key, relating question items to scales, presented in Appendix B. The inventory was initially produced in Dutch and then translated into English. The language of the question items is therefore fairly straight-forward and easy to understand, even for a second-language English speaker.

It is useful at this point to note again that the ILS identifies four key learning patterns: a meaning-directed learning pattern, a reproduction-directed learning pattern, an application-directed learning pattern and an undirected learning pattern. These four learning patterns are made up of four components of learning, namely, students' processing strategies, regulation strategies, learning orientations and conceptions of learning. Each of the various learning components have different scales (for example, deep, stepwise and concrete processing strategies), and students' scores for these scales are calculated by adding their responses (from 1 to 5) for question items relating to these scales (see Appendix C for summary).

4.3 The context

The second year Business Statistics course was used as the context in this case as the course is a pre-requisite for Bachelor of Business Science students and is more tailored to the commerce stream as opposed to the first year introductory statistics course, which caters for students in the commerce, science, engineering and humanities faculties. Therefore, although the course is a 'service' course to students in the commerce faculty programme, it is a pre-requisite for their studies and attempting to understand how students go about their learning in this course is important not only to those who teach the course but to the commerce faculty programme convenors and developers as well.

During the semester, students write three tests and complete three projects, two of which are completed online through the course website and the third is submitted as a written report. Students receive a year mark which is made up of a weighted average of these three test marks and three project marks. A final three-hour examination is written at the end of the course and the final overall mark for each student is made up of 60% of his or her final examination mark plus 40% of his or her year mark.

The teaching and assessment methods employed in this course are typical for a course in this discipline. The tests, projects, and examination set for the course were considered to be well aligned with the material and this was further confirmed through a good pass rate. Finally, the

structure and content of the course has not changed for a number of years and therefore the current group of students were not being taught, assessed or otherwise influenced in any 'new' way. The course is therefore thought to be a 'well-functioning' example of a typical second year Business Statistics course.

4.4 Data collection

The project was explained at length to the students during lectures, in an email and in an online announcement on the course website. Students used a login name and password to be able to access the course website and therefore the inventory was not available to the general internet public. This was also made clear to the author of the inventory. The inventory was made available online for a period of just under three weeks and three email reminders were sent to students during this time to remind them to complete the inventory if they wished. Students were also told that the results of their ILS would be made available to them, should they want to know which learning pattern they follow, according to the inventory. Approximately ten students indicated that they would like to receive the results of the inventory and this was done. The advantage of students submitting the inventory online was that results were immediately available in an Excel spreadsheet format and therefore hours of data capturing were not necessary.

As a measure of academic success student final overall marks were used as these are readily available and the only measure of academic success available in this context. These marks were also available in an Excel spreadsheet format as soon as the marking of examinations was completed and the results captured. This capturing occurs as part of the 'normal' functioning of the department and therefore extra work in terms of capturing the marks was not required.

It is also important to note that students were directed to answer the ILS in the context of the Business Statistics course, and not in the context of their learning in general.

4.5 The sample

In total, 258 students partook in the survey and completed the ILS online. The final number of registered students in the course was 686, which therefore yields a response rate of 38%. However, 14 students did not complete the questionnaire in full, and therefore only 244 fully completed questionnaires are available for use in the analysis. This however still yields a response rate of 36%, which can be considered to be fairly high given the fact that response to

the questionnaire was entirely voluntary. Reasons for this high response rate are not entirely clear, although I do believe that the three email reminders sent to students did help improve the response rate, as did the fact that students heard me speak of my research often during the time that I lectured them and were aware of how important their responses to the questionnaire were to me. On average, students took between 15 and 20 minutes to answer the questionnaire. It should be noted that the first four questions were answered by all students but that the number of non-responses increases to a maximum of 9 non-responses as the number of questions increases. It is assumed that certain students found the questionnaire to be too long and therefore stopped answering after a certain number of questions.

Allowing students to complete a questionnaire voluntarily online does raise concerns about the 'type' of students who end up being part of the final sample who responded to the questionnaire. Arguments could perhaps be made that only the most diligent and academically successful of students would answer the questionnaire, causing the sample to be biased. In order to determine whether a true difference between the sample and the population existed in this case, a simple test of the difference between the sample proportion of students who passed the course and the population proportion of students who passed the course was conducted. The null hypothesis under investigation therefore was that the proportion of students who passed out of those who answered the questionnaire was the same as the proportion who passed out of the class as a whole.

Using the final course results (including test, project and examination results), 95% of the 244 students who completed the entire ILS passed the course. Interestingly an identical proportion (95%) of the total class population who wrote the final examination passed the course. This confirms therefore that the sample is a good representation of the class population as a whole.

We turn now to a brief overview of the ethical issues surrounding the study.

4.6 Ethical issues

The ethical implications of the study were considered and it was not envisaged that any ethical concerns should arise from the present study, especially since there was no potential harm to students through the completion of the ILS. Students voluntarily completed the ILS online through the course website, and although this was not anonymous, it was assured that the raw data from the questionnaire would not be made publicly available and the reporting of the

results would be done in such a way as to ensure anonymity of student responses. Students also had knowledge of the background of the study and of the reasons behind the study being conducted, as these were discussed with them during course lectures. Students had full access, should they wish, to the final research report and to their own individual 'scores' on the ILS, and this was well advertised. The UCT Code of Ethics for Research Involving Human Subjects was consulted and, again, it was established that no further ethical concerns were likely to arise from the project. Ethics approval was applied for and granted through the Graduate School of Humanities using the standard ethics form.

4.7 Data analysis

In finding suitable ways to analyse the data obtained from an inventory, it is beneficial to examine the ways in which other users of the inventory have done so, as has been done in Chapter 3.

The techniques adopted in the studies reviewed were often found to be problematic and therefore, in terms of analysing the data for the present study, a different approach to those presented in Chapter 3 was therefore required. Firstly, it was necessary to determine whether any students had scale scores for the various components of learning which were significantly different to other scale scores for that component. For example, did any students stand out as having significantly higher scores for deep processing as opposed to stepwise or concrete processing strategies? A factor analysis was then conducted in order to verify whether or not the four learning patterns, as identified by Vermunt, were evident in the context of the second year Business Statistics course students in the present study. Individual question statistics, in terms of the number of students responding in particular ways to particular questions, were also examined and between-question correlations of related question items were calculated.

Finally, the predictive ability of the inventory was examined by calculating correlations between students' final marks and their scale scores, and determining through the use of appropriate tests whether a difference in average final marks existed for students satisfying certain criteria in terms of their responses to the ILS.

All of the analyses mentioned above are simple, yet statistically sound, ways of answering the research questions posed. Chapter 5 presents the results obtained from these analyses, using the data available in the present study.

CHAPTER 5

Results

This chapter examines the data obtained from student responses to the ILS and reports these results. Firstly, student scores on the various scales measured by the inventory are examined closely and significant differences in scores are identified, where applicable. The results from a factor analysis are then considered. Individual question statistics are also examined and questions identified as meeting particular criteria are looked at in greater depth. Between-question correlations for questions relating to the same scale are examined for significance and any departures from what would ordinarily be expected are noted. Finally, the predictive value of the inventory is examined in terms of the correlations between scale scores and students' final marks, as well as the difference in final marks for students having clearly identifiable scale score differences.

In some instances results are presented using the responses from all 258 students who completed the ILS, although 14 of these students presented incomplete questionnaires. At other times, only the 244 fully completed questionnaire responses are used. This difference is made clear in each case, and the reasons are given for the choice of either omitting or including the 14 incomplete responses.

The chapter ends with a brief overview of the results. A full discussion of all results is presented in the following chapter, and therefore there is only limited interpretation of the results in the current chapter.

5.1 Examining the ILS scales

Vermunt (2005) describes four learning components as making up a student's learning pattern. These include processing strategies, regulation strategies, orientations to learning and conceptions of learning, as mentioned already in Chapter 2. Each of these components are in turn made up of a number of scales, three each for processing and regulation strategies and five each for learning orientations and conceptions. According to the scoring key for the 100-item version of the ILS (Vermunt, 1994), total scores for each scale are calculated by adding the students' scores for particular questions. As an example, for the scale 'concrete processing', which falls under processing strategies, a score is computed by adding the students' responses

(from 1 to 5) for questions 3, 14, 21, 45 and 48. Although Vermunt does not take these scale scores and add them together to calculate pattern scores, for example, a score for 'meaning-directed' learning pattern, others have done so (for example see Busato et al 1998 and 1999). A key point to be made here is that, by adding question scores, the implicit assumption is made that the data, namely students' responses 1 to 5, fall on an interval rather than an ordinal scale, as mentioned in Chapter 3. Another assumption made by adding question scores is that the related questions measure the same aspect of student learning. Despite this, in order to be able to use the inventory in a way which was intended, the calculation of scale scores was done for all 244 students who completed the entire ILS in the way specified in the scoring key for the inventory (Vermunt 1994). In addition however, for each scale, the total score for each student was divided by the total possible score for that scale in order to obtain a scale score of between 0 and 1. This was done in an attempt to standardise the scale scores as a proportion of a total, instead of merely having a sum of all relevant question responses, with no idea of the relative value of the score.

It appears to be the case from studies using the ILS that the inventory has not previously been used as a tool to 'categorise' students according to certain learning patterns or even scales (see Chapter 3, Section 3.3). This could perhaps be questioned as there may be value in being able to categorise students according to their various learning patterns. For example, in terms of processing strategies, could one categorise a student as employing primarily deep, stepwise or concrete processing strategies according to his or her answers to certain questions and therefore his or her score for that particular scale? One would assume that students who employ primarily deep processing strategies, for example, would obtain the highest scores on this scale as opposed to their stepwise and concrete processing scores. However, simply taking the highest score for each scale is not sufficient if the difference between scores is not statistically significant. It was therefore decided, for the purposes of the present study, to determine which students had significant differences between their scale scores and could therefore be categorised as employing primarily certain processing and regulation strategies, and orientations to and conceptions of learning. Using a 5% level of significance, it was established that a difference of at least 0.2 was required between scale scores in order for the difference to be significant. Using this criterion, the number of students with no discernable differences in scores was counted, as well as those having clearly significant differences in scores, with one scale dominating the rest. For some students, two scale scores were

significantly higher than the others for a particular learning component, and a 'mix' of scales was therefore established.

The number of students satisfying the criteria of having no discernable difference in scale scores for the processing strategies component of the ILS, and those with a discernable difference in scores, are shown in the table below.

	No. students	%
Processing Strategies		
no discernable difference in scores	161	66%
deep processing	0	0%
stepwise processing	60	25%
concrete processing	5	2%
deep/stepwise mix	13	5%
deep/concrete mix	2	1%
stepwise/concrete mix	3	1%

Table 1: number of students with scale score differences for processing strategies component

Immediately evident is the high percentage of students who had no discernable differences in scale scores for processing strategies, and the fact that no students could be classified as adopting exclusively deep processing strategies. Also evident is that, for those students with discernable differences in processing strategies, 25% of all students fell into the stepwise processing group, therefore employing mainly memorising, rehearsing and analysing of material when it came to learning for the course. A small number of students employed primarily concrete processing strategies, and small percentages adopted a 'mix' of two of the three main processing strategies.

Table 2 below shows the statistics for the regulation strategies component of the ILS.

	No. students	%
Regulation Strategies		
no discernable difference in scores	83	34%
self regulation	1	0%
external regulation	85	35%
lack of regulation	7	3%
self/external mix	23	9%
external/lack mix	45	18%

Table 2: number of students with scale score differences for regulation strategies component

The distribution of students in this case showing discernable and no discernable differences in scores is less skewed than for the processing strategies component above, although very few students show self regulation strategies or a lack of regulation. Approximately one third of students showed no discernable difference in scale scores, while another third showed primarily external regulation strategies, meaning that they learnt mainly according to instructions and direction given by the lecturers, and also through the use of materials such as past test and examination papers. Another 27% of students relied on a mix of self or external regulation or showed a mix of external regulation coupled with a lack of regulation.

Table 3 shows the same information for the learning orientations component of the ILS.

	No. students	%
Learning Orientations		
no discernable difference in scores	184	75%
personally interested	0	0%
certificate driven	0	0%
self-test driven	5	2%
vocation driven	19	8%
ambivalent	0	0%
certificate/self-test mix	1	0%
certificate/vocation mix	8	3%
personal/vocation mix	1	0%
self-test/ambivalent mix	1	0%
self-test/vocation mix	25	10%

Table 3: number of students with scale score differences for learning orientations component

Three quarters of students who answered the ILS showed no difference in scores when it came to the learning orientations component. Furthermore, no students were found having primarily personally interested, certificate driven or ambivalent learning orientations. However, a small percentage did show clear vocation driven orientations and a mix of self-test and vocation driven orientations. The results for the conceptions of learning component are even more skewed, as shown in the table below.

	No. students	%
Conceptions of Learning		
no discernable difference in scores	219	90%
construction of knowledge	0	0%
intake of knowledge	6	2%
use of knowledge	3	1%
stimulating education	0	0%
co-operative learning	0	0%
construction/use mix	2	1%
intake/stimulating mix	1	0%
intake/use mix	11	5%
use/co-operative mix	2	1%

Table 4: number of students with scale score differences for conceptions of learning component

Here, a remarkable 90% of students showed no discernable difference in scores, with a very small percentage of students showing any discernable difference in the primary conceptions of learning scales.

From the results shown above for the four components of learning measured by the inventory, it appears that the regulation strategies component provides the most discernable differences in student scores and provides the greatest number of students that can be clearly 'categorised' as having a primary regulation strategy (35% of students were shown to adopt external regulation strategies). The second most discernable component is the processing strategies component, where 25% of students were shown to adopt primarily stepwise processing strategies in their learning. The learning orientations component appears to be very unclear in terms of identifying primary learning orientations among students (only a very small 8% were shown to be vocation driven in their learning) and the conceptions of learning component is even more unclear in that 90% of students are shown to have no discernable difference in scores and therefore no primary conception of learning, as measured by the inventory.

We turn now to the results of a factor analysis conducted using the 244 completed student responses to the ILS.

5.2 Results from a factor analysis

In order to conduct a factor analysis, it should again be noted that the usual assumption is that the data fall on an interval rather than an ordinal scale. This is because factor analyses are conducted based on correlations between various variables, and these correlations necessarily assume that interval data is being used. A factor analysis conducted on the scores for the 16

scale variables of the questionnaire identified four predominant factors, which together accounted for just over 60% of the total variation in the data, a percentage which can be considered quite high. The factor loadings for the four factors are shown in a table in Appendix D. Factors loadings above 0.5 will be considered high in this study. Although one would not expect identical factors to those obtained by other researchers, simply due to the differences in samples, some alignment with the theory behind the inventory would be desirable and would be a way of validating the use of the inventory in this case. The factor loadings for each factor identified in the present study were therefore compared for links with the four factors identified by Vermunt (2005).

The first factor identified in the factor analysis results conducted here show strong factor loadings for deep processing strategies and self regulation of learning, which initially suggests similarities to the meaning-directed learning pattern identified by Vermunt. However, concrete processing strategies also come up strongly whilst construction of knowledge and a personally interested learning orientation do not really show up significantly at all. According to factor analyses conducted by Vermunt (2005), a meaning directed learning pattern should show high factor loadings for deep processing strategies, self regulation strategies, construction of knowledge as a conception of learning and a personally interested learning orientation. The first factor therefore seems to show links with the meaning-directed learning pattern, although the inclusion of the concrete processing strategy is not in accordance with theory.

Results for the second factor showed a strong factor loading for the certificate directed learning orientation, as well as fairly strong factor loadings for external regulation and the intake of knowledge as the conception of learning. As mentioned in Chapter 2, a reproduction directed learning pattern as identified by Vermunt should show strong factor loadings for is stepwise processing strategies, external regulation strategies, the intake of knowledge as a conception of learning and a certificate and self-test learning orientation. The stepwise processing strategy did show up fairly strongly in this case (factor loading of 0.50) although this was not as strong as it appeared for the first factor. A low factor loading for self-test learning orientation was obtained. This indicated that the second factor showed links with the reproduction-directed learning pattern identified by Vermunt, although it was not identical to this factor.

The third factor showed fairly strong factor loadings for the construction of knowledge, and the personal, self-test and vocation directed scales, although these were all below 0.7. This factor

therefore did not appear to link directly to any of the learning patterns identified by Vermunt and is therefore perhaps the most 'out of line' with the theory.

The fourth factor identified showed the three strongest factor loadings as being for the lack of regulation, co-operative conception of learning and ambivalent learning orientation. This factor was therefore perhaps the most strongly in agreement with Vermunt's theory, as it showed direct links with the factors associated with an undirected learning pattern.

It seems, therefore, that although four primary factors were identified and that these accounted for a fairly large proportion of the variation in the data (approximately 60%), the factors identified are not clearly in agreement with those identified by Vermunt. Perhaps the most clearly identifiable factor, and the one most in agreement with the theory, would be that for the undirected learning pattern, whereas the 'weakest' factor according to alignment with theory would be that for the application-directed learning pattern, which, it may be argued, is not present at all.

Given the results from this factor analysis, categorising students according to the four learning patterns, by taking the sum of their scores for various questions, would not be advisable, as the factors identified here do not appear to correspond directly with those identified by Vermunt. Also, as identified in Section 5.1 above, very few students actually show a discernable difference in their scale scores and therefore simply adding these scale scores together to produce a score for a particular learning pattern would not make sense.

We look now at student responses to individual questions from the inventory, and the statistics that can be drawn from these.

5.3 Examining individual question statistics

A summary of the responses to each question is presented in Appendix E. This shows the number of non-responses to each question (column headed '-') as well as the number of students choosing either option 1, 2, 3, 4 or 5 of the Likert-scale responses for each question. The responses of all 258 students who started responding to the questionnaire are included here, even those of the 14 students who did not complete the questionnaire in its entirety.

Although one would not expect equal numbers of students to choose responses 1 to 5 for each question, it is interesting to note those questions for which responses are particularly skewed towards one of the options 1 to 5. The four questions with the most skewed results are shown in the table below.

No.	N	Question statement	Responses
16	255	In addition to the syllabus, I study other literature related to the content of this course	**214** students reponded "I do this seldom or never"
39	254	I add something to the course material from other sources (for example, the internet, TV, other books)	**186** students reponded "I do this seldom or never"
62	252	For the kind of work I would like to do, I need to have studies in higher education	**183** students responded "Agree entirely"
94	251	I prefer it when I am told exactly what I need to know for the exam	**171** students responded "Agree entirely"

Table 5: questions showing extremely skewed student responses

For each of the questions listed above, the number of students responding to the particular option mentioned is over three times the number that would be expected if equal numbers of students had chosen each question response option (that is, the number of students answering the question, divided by the five answer options).

The questions for which there is no statistically significant difference in the number of students choosing each option (that is, all options are selected by an approximately equal number of students) are presented below. These are selected according to the chi-squared goodness-of-fit test, which examines the way in which specific data 'fits' a certain pattern or distribution. The null hypothesis therefore is that an approximately equal number of students chose each answer option (1 to 5). A sufficiently high p-value (in this case chosen to be over 1%) would lead us to not reject this hypothesis and conclude that the distribution of answers for those particular questions is indeed approximately equal.

No.	N	Question statement	Chi-squared p-value
1	258	I work through a chapter in the textbook or in the notes item by item and I study each part separately	p-value > 0.01
10	256	I try to discover the similarities and differences between the different theories that are dealt with in this course	p-value > 0.01
20	255	To test my learning progress once I have done some studying, I try to formulate the main points in my own words	p-value > 0.05
29	255	If I am able to give a good answer to the questions posed by the lecturer, then I feel that I understand the course material well	p-value > 0.01
54	252	I doubt whether statistics is the right subject area for me	p-value > 0.05
86	251	I prefer to do assignments or projects in a group with other students	p-value > 0.01

Table 6: questions showing equal distribution of student responses

The remaining 90 questions all showed skewed results at a 1% level of significance in terms of student answers, although none were quite as skewed as the four questions presented in Table 5 above.

Also of interest are the questions for which no students chose a certain response. Three of these questions arose, and these are presented below.

No.	N	Question statement	Responses
68	251	What I want to acquire above all through my studies is professional skill	**0** students responded "Disagree entirely"
88	250	I have a preference for courses in which a lot of practical applications of the theoretical parts are given	**0** students responded "Disagree entirely"
90	249	To me, learning means acquiring knowledge that I can use in everyday life	**0** students responded "Disagree entirely"

Table 7: questions showing zero student responses to certain answer options

5.4 Between-question correlations

As already mentioned, the scale scores for students who completed the ILS were calculated by adding together question items, as identified by Vermunt's (1994) scoring key for the inventory. For example, to obtain a score for the personally interested learning orientation, one would add together student scores for questions 52, 60, 64, 69 and 73. Since questions which are grouped together in this way are essentially asking about similar aspects related to learning and studying, one would expect individual students to answer the questions in a similar 'direction',

so to speak. One would therefore expect positive relationships between the responses of related questions. Correlation matrices for all 16 scales were calculated and, indeed, these did show significant positive relationships between the majority of related questions, although the correlations were somewhat low, with the highest positive correlation being 0.59. The correlation matrices are displayed in Appendix F.

Interestingly, significant negative correlations occurred within the questions related to the certificate-directed learning orientation. This means that, when students gave a higher response score to a particular question, they tended to give a lower response score to a related question. Responses to question numbers 58, 63 and 65 all had significant negative correlations with question 55, although all of these questions were supposed to measure how 'certificate-directed' a student was in his/her learning orientation. These three questions, as well as the correlations with question 55, are summarised in the table below.

No.	Question statement	
55	I aim at attaining high levels of study achievements	
No.	**Question statement**	**Correlation with question 55**
58	The main goal I pursue in my studies is to pass the exams	-0.32
63	What I want out of this course is to earn credits towards my degree	-0.16
65	I study above all to pass the exam for this course	-0.18

Table 8: questions showing significant negative correlations with question 55

A few remaining correlations were insignificant while, as mentioned, the majority of correlations were positive and significant, as would be expected for related question items. Again, one should note that the implicit assumption being made here is that the data are on an interval rather than an ordinal scale. Since this assumption was made for the factor analysis, and given the fact that the factor analysis is largely based on inter-question correlations, we are justified in making the same assumption in this case.

5.5 Examining the predictive nature of the inventory

One of the research question posed in Chapter 1 was whether the inventory had any predictive value, in terms of predicting which students were more likely to succeed in the course, given their responses to the ILS.

Since the factor analysis results presented in Section 5.2 show factors inconsistent with those obtained by Vermunt and others, it was decided that categorising students according to the four learning patterns as identified by Vermunt would be unwise. Care should also be taken when categorising students according to their scale scores, for example, categorising students as having personally interested learning orientations or displaying a lack of regulation of learning. This was because, as discussed in Section 5.1 above, most students could not be found to have any discernable difference between their scale scores.

In two learning components a relatively large group of students could be classified as displaying primarily certain learning strategies, given their significantly different scores for these scales as compared to their other scale scores in the particular learning component. For the processing strategies component, 25% of students clearly displayed stepwise processing strategies (66% showed no discernable difference in scores), and for the regulation strategies component, 35% of students showed external regulation strategies (34% showed no discernable difference in scores). It was decided to conduct t-tests to determine whether a difference in average final marks existed for those students who showed a clear difference in scale scores for these components. It should be noted here that the final marks were first checked to ensure that they followed a normal distribution, which is one of the conditions that needs to be met before a t-test can be conducted.

The results from the t-tests are shown in Appendix G. No difference in average final marks was found between students showing no discernable difference in processing strategies (two-tailed p-value = 0.25) and those showing clear stepwise processing strategies. Therefore students who processed material through memorising, rehearsing and analysing, did not, on average, do any better or worse than those who showed no clear processing strategies. However, in terms of regulation strategies, students who adopted clear external regulation strategies did significantly better, on average, than those students who showed no clear regulation strategies (one-tailed p-value = 0.002). This is an interesting result, showing that students who learnt the subject material according to instructions given by others (mostly the lecturers), and by relying on materials such as past test and examination papers to help them in their studying, did significantly better than those who had no clear strategy in the regulation of their learning and studying.

As a final measure of the predictive value of the inventory, it was decided to calculate the correlations between students' scale scores and their final results. Although this is overall a weak measure of predictive value of the inventory, it does give some indication as to the direction in which scale scores and final marks are moving when compared to each other. Again the assumption is made that the scale scores fall on an interval rather than ordinal scale. The correlations are shown in table 9 below.

Scale	Correlation with final mark	Significant?
Processing Strategy		
Deep	0.16	no
Stepwise	0.15	no
Concrete	0.05	no
Regulation Strategy		
Self	0.10	no
External	0.16	no
Lack	*-0.23*	yes, at 1%
Learning Orientation		
Personally interested	0.07	no
Certificate directed	*-0.21*	yes, at 1%
Self-test directed	-0.05	no
Vocation directed	0.10	no
Ambivalent	*-0.29*	yes, at 1%
Conception of Learning		
Construction of knowledge	-0.03	no
Intake of knowledge	-0.04	no
Use of knowledge	-0.01	no
Stimulating education	0.12	no
Co-operative learning	*-0.27*	yes, at 1%

Table 9: correlations between scale scores and final marks

Only four of the sixteen correlations showed up as significant at the 1% level. The remaining twelve correlations were insignificant, showing that no real relationship existed between students' scores for those scales and their final results. The four correlations that were significant were interestingly all negative correlations. These showed that students who scored higher on the lack of regulation, certificate-driven orientations, ambivalent orientations, and co-operative conceptions of learning scales, generally received lower final marks. However, whilst significant, the correlations are still small, with the largest being -0.29. Also, it should be noted that no students showed discernibly different scores for co-operative learning, certificate-driven or ambivalent orientations, and only a very few showed discernable scores for a lack of

regulation. Therefore, although the general trend was for students who scored higher on these scales to received lower final marks, none of these students could be classified as adopting the above learning strategies, conceptions or orientations exclusively. As mentioned, the correlations are helpful in providing some idea of the general direction and relationship between these scale scores and final results. It is also interesting to note that three of the four significant correlations correspond to scales identified in the theoretical framework as belonging to an undirected learning pattern. These are a lack of regulation, an ambivalent learning orientation and a co-operative conception of learning

5.6 Overview

This chapter has presented the results obtained from student responses to the ILS, both in terms of the responses on their own and the relationship between the responses and students' final results.

Initial analysis of scale scores showed very few students as having one or two scale scores which were significantly different from other scale scores for the same learning component. The processing strategies component showed 66% of students having no discernable difference in scores, whilst 25% could be shown to exhibit mainly stepwise processing strategies. In terms of regulation strategies, 34% of students showed no discernable difference in scale scores, but 35% were shown to rely on primarily external regulation strategies. For the learning orientations and conceptions of learning components respectively, a startling 75% and 90% of students showed no discernable difference in scale scores, making these the two most indistinguishable learning components in terms of being able to 'categorise' students as adopting particular orientations to and conceptions of learning.

A factor analysis of the responses confirmed the presence of four primary factors in the inventory. However, these did seem to deviate somewhat from the factors identified by Vermunt. The strongest factor overall appeared to be the fourth factor, or undirected learning pattern.

Analysis of individual question statistics, in terms of number of responses per answer option, showed interesting results. The actual question statements for those questions reporting extremely high or extremely low numbers of students choosing particular responses were presented, as well as those for which an approximately equal number of students chose each

available option. Correlations of responses between related questions showed generally significantly positive correlations as was to be expected. A few significantly negative correlations were identified and the question statements pertaining to these questions were presented.

Statistical tests of the difference in final results between students who showed no discernable difference in scale scores and those showing a clear preference for certain processing and regulation strategies, identified a difference between students adopting external regulation strategies and those showing no clear regulation strategies. Finally, correlations between scale scores and final results identified four significant correlations, all negative, and primarily related to scales in the undirected learning pattern.

The following chapter contains a discussion based on the results presented above.

CHAPTER 6

Discussion of the Results

The discussion in this chapter will focus around each of the sets of results in turn, as presented in Chapter 5, and will conclude by drawing together the main points that can be made regarding the results.

Throughout the following discussion, two considerations are to be kept in mind. Firstly, an inventory such as the ILS can only really be considered valuable if it is practically useful for teachers and provides opportunities for the teaching and learning experience to be enhanced (Biggs, 1993). Secondly, as mentioned in Chapter 1, the Business Statistics course used in the present study is a service course, and therefore students completing the course are doing so out of necessity for degree purposes and have not necessarily chosen to do statistics, but have rather been 'forced' to do it. This point is important to keep in mind when trying to interpret some of the sometimes startling results presented in Chapter 5.

We turn now to a discussion of the results.

6.1 The 'categorisation' of students

Section 5.1 of Chapter 5 set out an argument against merely taking the maximum scale score in any particular learning component and classifying a student as such. For example, if the student's score for external regulation was the highest amongst his or her three scale scores for regulation strategies, then simply classifying the student as adopting external regulation strategies was not advisable. Only if the difference between the three scale scores for that particular component was significantly higher for external regulation could one reasonably assume that the student adopted primarily external regulation strategies. In examining which students gave responses to the inventory which resulted in significantly different scale scores for certain scales, it was shown that, for each learning component, a large percentage of students actually had no discernable difference in scores. This percentage was particularly high for the learning orientations component, where 75% of students showed no discernable difference in scored, and for the conceptions of learning component, where 90% of students showed no discernable difference in scores. The result was that the large majority of students

were not 'classifiable' as such, in terms of the components of the different learning patterns as identified by the ILS.

It appears that the inventory was not initially intended as a tool by which to categorise, or distinguish or discriminate between, students for whatever reasons. However, if the inventory is to be utilised as a tool for teachers, then perhaps being able to identify students more clearly in terms of their processing strategies, regulation strategies, learning orientations and conceptions of learning would be useful? In terms of students who could be categorised according to their responses and resulting scale scores, it is interesting to note that a quarter of students (25%) could be identified as adopting stepwise processing strategies, which involve memorising, rehearsing and analysing material. Furthermore, over a third of students (35%) were shown to adopt primarily external regulation strategies, therefore learning according to how they were advised to by lecturers and through the use of materials such as past test and examination papers. These results could perhaps be seen as an artefact of the course, as a large proportion of the course does involve formulae and the memorisation of these formulae, as well as the ability to apply these formulae to datasets in order to generate results. Concepts are taught by example and repeated examples of the same type are often presented in order to allow students the opportunity to 'practice' or rehearse what they have been taught. In terms of study and learning techniques, students are also frequently advised by lecturers as to how they should go about their studying, and are often told that practicing the material by attempting a previous year's test or examination paper would be appropriate. Perhaps, therefore, the fact that such a relatively large group of students can be classified according to the processing and regulation strategies mentioned above should come as no surprise.

Another interesting result obtained from the analysis of scale scores, was the fact that virtually no students could be classified as adopting deep processing strategies or self regulation strategies (one student fell into this group), or as having personally interested learning orientations or viewing learning as the construction of knowledge. These could perhaps all be viewed as 'desirable' characteristics of learning and fall into what Vermunt (2005) terms a meaning-directed learning pattern. Again, the question should be asked whether this phenomenon is merely an artefact of the course in question, and the fact that students are 'pushed' in some sense towards learning in a particular way, as mentioned above. Are we, as teachers of the course, promoting and facilitating the adoption of meaning-directed learning patterns?

It seems, therefore, that the results of the students' scale scores show more about the course and how it is taught than about the students and how they go about their learning. For example, it is hard to imagine that, in a group of approximately 250 students, none would display primarily components of a so-called meaning-directed learning pattern. It is however easier to assume that those students who might ordinarily, or in other courses, adopt meaning-directed learning patterns, would in this course learn according to how they are advised to, perhaps seeing this as the easiest route to success. It may therefore be that these students are adopting a so-called 'achieving' approach to their learning, as mentioned by Entwistle and McCune (2004).

6.2 Examining the theoretical basis of the ILS

A factor analysis of student responses to the ILS revealed four primary factors, although these were not completely in alignment with the factors identified by Vermunt. This 'misalignment' could be the result of one of three things.

Firstly, it may be because of the way in which students are answering the questionnaire that the factors are not as they 'should' be. However, there is no reason to believe that students were untruthful in their responses, given the fact that they were not coerced in any way to partake in the survey and did so entirely voluntarily. It is not imagined therefore that students simply chose answers at random when completing the inventory. Also, in terms of language, the questions were simply worded (see Chapter 4, Section 4.2) and, given the fact that the students are all studying at second year level or higher in an English university, there was unlikely to be a problem of lack of understanding on the part of the students.

The fact that the factors identified in the present study are not in line with those identified by Vermunt is therefore either a result of the course itself or a consequence of the theoretical assumptions upon which the inventory is based. The Business Statistics course is this case is not unique in its characteristics and is merely an exemplar of the 'typical' scientific, technical course in which much factual knowledge is required and the application of standard formulae and procedures to various situations is expected. To date, the ILS has not been sufficiently tested in a course such as this one (see Chapters 2 and 3) and, although learning is generally accepted as being contextual, it is nowhere mentioned that the ILS is only applicable to courses in the humanities, for example, and not the sciences. It would seem therefore that the theoretical assumptions upon which the inventory is based can be called into question in this

particular context, as a theoretically sound inventory should be responsive to the features of the more technical courses. Indeed, Vermunt and Minnaert (2003), as mentioned in Chapter 3, conclude that if the 'dissonance' in learning patterns is a result of the theoretical assumptions underlying the inventory, then these assumptions and the inventory itself need to be revised.

As a result of this misalignment with theory, it became necessary to look at the inventory and the student responses on a question-by-question basis rather than looking at responses as a whole. This is done in the section below.

6.3 What individual questions tell us

Seven questions from the ILS were identified as having very skewed response rates in terms of the number of times students selected certain response options for these questions. Four questions were identified as having very high response rates for certain answer options, and three questions were identified as having zero responses for particular options. These questions were presented in Tables 5 and 7 of Chapter 5 respectively.

In terms of the first criterion, 84% of students who responded to the ILS chose the answer option "I do this seldom or never" when responding to the statement "In addition to the syllabus, I study other literature related to the content of this course". 73% of respondents indicated "I do this seldom or never" when responding to the statement "I add something to the course material from other sources (for example, the internet, TV, other books)". The response rates to these particular questions seem to indicate that the students in this course, in general, tend to learn from whatever material is given to them, and very few make an attempt to find information elsewhere that is related to the content of the course. Both questions also relate to the self regulation strategy of the learning components, which only one student could be clearly identified as adopting (see Chapter 5, Section 5.1).

73% of respondents chose the answer option "Agree entirely" to the statement "For the kind of work I would like to do, I need to have studies in higher education" while 68% answered "Agree entirely" to the statement "I prefer it when I am told exactly what I need to know for the exam". The first statement refers to the vocation-driven learning orientation and the second to the conception of learning as the intake of knowledge, as well as the regulation of learning being external. The majority of students in the Business Statistics course are studying towards professional qualifications, for example to be Chartered Accountants, and therefore the large

number of respondents agreeing with the first of the two statements is not surprising, given that university degrees are genuinely required for these qualifications. The second statement confirms that students in the course seem to be studying according to how they are told to, and this points again perhaps at the structure of the course rather than the actual learning patterns of the students.

In terms of question statements where none of the students chose a particular answer option, three such questions were identified, as shown in Table 7 of Chapter 5. For all three question statements, no students selected the response "Disagree entirely". The first statement was "What I want to acquire above all through my studies is professional skill". The fact that no students disagreed with this, emphasises again the vocation-driven learning orientations of many of the students and the fact that many, out of necessity, need university degrees for their chosen professions. The second and third statements to which no students responded "Disagree entirely" were "I have a preference for courses in which a lot of practical applications of the theoretical parts are given", and "To me, learning means acquiring knowledge that I can use in everyday life". These statements indicate the conception of learning as the practical use of knowledge, and the fact that no students disagreed entirely with the statements indicates that students who responded to the ILS prefer knowledge which they can practically apply, as opposed to theoretical knowledge. Students were directed to answer the ILS in the context of the Business Statistics course, and we can therefore assume that in particular, when it comes to studying statistics, students prefer this practical as opposed to theoretical knowledge. This is something that is also emphasized in the teaching of the course.

6.4 Looking at between-question correlations

An analysis of between-question correlations of related questions in the inventory produced some interesting correlations, particularly those which were significantly negative. As was mentioned in Section 5.4 of Chapter 5, questions 58, 63 and 65 all correlated negatively with question 55, even though all questions were supposed to measure the same component of learning, in this case the certificate-directed learning orientation. The question statements are set out in Table 8 of Chapter 5.

It is interesting to note that question 55 refers to the attainment of "high levels of study achievement" whereas questions 58, 63 and 65 refer simply to passing the exams or obtaining credits towards a degree. The fact that questions 58, 63 and 65 correlate negatively with

question 55, means that those students with higher scores on question 55 tended to score lower on the other three questions and vice versa. There are two possible explanations for this.

Firstly, the wording of question 55 may be seen as somewhat odd. The question reads "I aim at attaining high levels of study achievements". In everyday English language, the term "study achievements" is not often used and this may have confused some students. Some might believe "high levels of study achievements" to mean attaining "higher degrees" such as a masters or doctorate degree. However, one would assume that students at this level would perhaps associate "high levels of study achievements" with high marks and good grades. Therefore, although the wording of the question is potentially somewhat confusing, I do not believe that it would have influenced results to such an extent as to make the correlations as significantly negative as they were.

The second explanation is that students see a difference between merely passing and getting through the course, and doing well and getting high marks. As mentioned, questions 58, 63 and 65 refer to merely passing the course or obtaining credits towards a degree, whereas question 55 refers specifically to doing well. The significantly negative correlations between these questions might therefore mean that those who want to do particularly well care less about just passing or obtaining degree credits, while on the other hand, those who do just wish to pass the course and obtain credits, care less about doing particularly well.

6.5 Examining the predictive validity of the ILS

The predictive nature of the inventory was examined in two different ways and these results were presented in Section 5.5 of Chapter 5. Firstly, t-tests were done to determine whether any significant differences existed in the marks of students who could be categorised as adopting certain regulation and processing strategies and those who could not. Secondly, correlations between students' scale scores and final marks were calculated.

In terms of the t-test results, it was shown that students who adopted external regulation strategies (35% of those who responded to the ILS) did significantly better than those who could not be classified as adopting any one particular regulation strategy for their learning (34% of students). It seems therefore, that those students who are learning according to how they are encouraged to by the lecturers are doing significantly better than those who are not necessarily learning as they are expected to. It may be that the more conscientious students are the ones

who 'do as they are told to', and therefore, in the end, obtain the better results. These students might therefore be adopting whatever means they see fit in order to obtain the best results, something similar to the achieving approach mentioned by Entwistle and McCune (2004). An achieving approach or learning pattern is not specifically identified in the ILS and is one of the major criticisms levelled against it by Entwistle and McCune (see Chapter 2, Section 2.4). Perhaps the inclusion of this type of learning pattern might be advantageous as it would determine, especially in this particular context, whether students are learning in whatever way they see fit in order to achieve good results.

In terms of the correlations calculated between students' scale scores and their final marks, the negative correlations proved to be interesting, especially those of the co-operative conception of learning. These showed that students who value working together with other students generally do worse than those who work alone. Vermunt (2005) found the same phenomenon to be true in his study of Dutch university students. The result is astonishing as one would imagine that those students who work together in groups would learn from one another and therefore do better overall than those who did not work in co-operation with others. It may be however that the 'more able' students do not see the need to work together with others as they are able to manage the material on their own, and it is the weaker students who may generally be getting together and working in co-operation with each other. The question needs to be asked therefore whether these groups of perhaps 'weaker' students are not perpetuating what may be wrong ideas about the materials and perhaps even bad study habits. It may also be an indication that more supervised group work such as organised tutorial sessions (of which there are currently none) are needed for the course in order to get those students who are not managing with the material 'on track' and perhaps interacting with a more diverse group of students in the course.

In terms of the correlations, as pointed out in Chapter 5, it is interesting to note that three of the four significantly negative correlations between scale scores and final marks occurred for scales related to the undirected learning pattern, as identified by Vermunt (2005). One would expect students who show a lack of regulation of their learning and an ambivalent learning orientation, for example, to not do as well as those who were more directed in their learning, and it is therefore no surprise to find the same result in this case. However, one should ask whether the emergence of these 'undesirable' regulation strategies and learning orientations might not again be an artefact of the course as opposed to the individual learning patterns of the students.

Given the fact that the course is a service course and is therefore 'forced' upon the majority of students, rather than an optional course which students willingly elect to do, one might expect to see some of the undesirable responses emerge.

In conclusion then, in terms of the predictive value of the inventory, it seems that the ILS cannot be comprehensively used to determine whether individual students are more likely to fail or pass the course given their responses to the ILS. However, the student responses and the results of the t-tests and correlations do say something about the nature of the course. In particular, it seems that there are students, perhaps the more conscientious ones, who do better if they study according to how they are directed to. This does raise questions about what sort of knowledge is valued in the course, and suggests that perhaps ways of encouraging understanding of concepts rather than mere application of knowledge and memorisation of methods and formulae are needed. Also, it seems that, for some reason, those working together in co-operation with other students tend to do worse in terms of their final results. This may suggest the need for greater intervention on the part of these students who are struggling to come to grips with the material.

The following chapter concludes this thesis by revisiting the research questions initially posed in Chapter 1 and answering these given the results and the discussion presented in Chapters 5 and 6. The implications for practice are briefly examined, and possible future studies are discussed.

CHAPTER 7

Conclusion

This chapter concludes the present study by reviewing the research questions presented in Chapter 1, and attempting to answer these given the results and discussion of the results presented in Chapters 5 and 6 respectively. Implications for practice as well as possible future research are also explored.

In short, the research questions, as presented in Chapter 1 were:

a. Do the learning patterns as identified by the ILS appear in the sample of second year Business Statistics students in the present study?

b. Does the ILS have any predictive value in determining whether students pass or fail the course depending on their responses to the ILS?

An additional area addressed in the present study, although not specifically one of the research questions, was the identification of effective ways of statistically analysing the data obtained from inventories in general and the ILS in particular.

7.1 The identification of learning patterns

The ILS was the inventory of choice for the present study for a variety of reasons. These were described in Chapter 2. Firstly, it was felt that the application-directed learning pattern, which is missing from other inventories, may have value in the context in question here. Secondly, the inventory was thought to be 'thorough' in its questioning about students' learning processes, orientations and conceptions, although it was admitted that the inventory, with 100 question items, is long. Thirdly, the incorporation of not only learning patterns but also the learning components which make up these patterns was thought to be valuable. Fourthly, the context in question here, that of a second year Business Statistics course at a South African university, was completely different to the contexts in which the inventory had previously been tested and this was thought to be of value. Finally, the inventory was found to be accessible to students in terms of the language used and the phrasing of its questions.

The theoretical assumptions underlying Vermunt's ILS suggest that four distinct learning patterns, made up in turn of four components of learning, should be evident when analysing the

responses of students to the inventory. These assumptions were tested in the present study using the thus far untested context of a scientific-based course, that of the second year Business Statistics course at UCT.

In answering the first of the research questions therefore, a factor analysis identified that four factors were indeed evident in the student responses to the ILS, although upon closer examination, these did not appear to be completely in agreement with those identified by Vermunt (2005). The clearest factor identified and the one with most similarities to the factors identified by Vermunt would be that of the undirected learning pattern. The remaining three factors, namely the meaning-directed, application-directed and reproduction-directed learning patterns, were not clearly evident in the student responses in this case. It appears therefore that the theoretical assumptions underlying the inventory did not apply when attempting to use the inventory in this particular context.

In addition to the factor analysis results, the examination of student scores for the learning components revealed that very few students could arguably be 'classified' according to certain learning components, and the vast majority therefore remained 'unclassified'. The grouping of students according to distinct learning patterns was therefore not possible and raised questions about what practical value the inventory had in terms of yielding information for teachers.

7.2 The predictive value of the inventory

In answering the second research question regarding the predictive value of the inventory, the results indicated that it is difficult to determine on the individual student level whether a student is more or less likely to pass the course, given his or her responses to the ILS. However, in general, it does seem that those students who adopt primarily external regulation strategies are more likely to do better in the course. This may suggest that these students are adopting an 'achieving' approach to their learning, whereby they learn as they are encouraged to by the lecturers and in a way that would ensure maximum marks. Whether adopting an achieving approach or not, the results clearly indicate that students who follow instructions as to how they should go about their learning tend to gain better final marks overall.

The results also showed that those who score higher on questions related to what can be termed an undirected learning pattern, in terms of having a lack of regulation, ambivalent learning orientations and a co-operative conception of learning, do seem to do worse on

average than those students who score lower in these questions. Therefore, in some sense, the inventory does have predictive value in that if we were able to pick out students who scored higher on questions related to an undirected learning pattern, we may be able to determine ahead of time that these students are 'at risk', meaning that they have a greater chance of achieving lower marks in the course. Deciding what exactly to do with this information, once we have it, is difficult, and may involve some sort of intervention programme in the learning methods of these students. This is an interesting implication given that Veenman et al (2003) say that the inventory cannot be used to identify students at risk (see Chapter 3). The implications of this are discussed further in Section 7.4 below.

7.3 Analysing the data effectively

In terms of effectively analysing the data obtained from the inventory, certain methods have been adopted here which, although not involving very advanced statistics, are correct. Firstly, the extent to which the sample represents the population of interest was tested through a simple test of proportions. This is important to do at the beginning of a study in order to justify that the results and inferences based on the results of the sample may be extended to the population as a whole.

Secondly, if students' scores on particular items are to be used in any way in order to categorise these students, it is first necessary to test whether the difference in scores is statistically significant enough for classification based on the highest score to take place. Tests to determine whether differences exist in the marks for students falling into various categories (t-tests) can then be appropriately conducted, however, it is important to first test whether the data follow a normal distribution. In terms of conducting factor analyses and calculating correlations of any sort, it is vital to state upfront that it is assumed that any data for Likert-type questions fall on an interval rather than an ordinal scale.

A final type of analyses which was conducted here and has not to date been done in any other studies involving the inventory, is the examination of student responses on a question-by-question basis. This is simple to do, and questions for which responses are particularly skewed can provide important insights into both the nature of the students learning and the nature of the context in question.

7.4 Implications for practice

At the conclusion of this study it is still believed that the ILS has enormous value in many respects. The inventory is thought to be thorough, with the language easily accessible and understandable for the most part. The breakdown of learning patterns into components also makes for interesting research and is an important addition not often seen in other student learning inventories.

In the present study, a few students did request to know the 'results' of their completion of the inventory. It may be valuable to continue to make this service available to students who respond to the ILS in future, although it is likely to be the case that those students who most need help in terms of their learning are those less likely to take the opportunity to get help as they already display a lack of regulation and/or an ambivalent learning orientation. Caution should also be expressed in offering 'advice' to students based on their responses to the inventory as the results obtained appear to relate primarily to the course as a whole, rather than to students as individuals.

The results of the present study, as already mentioned, have served to show more about the way in which the course is perceived by the students and run by the teachers, rather than the way in which students go about their learning for the course. It is important therefore, as teachers of the Business Statistics course, to ask whether the presentation and structure of the course should be re-examined. In terms of the value of the inventory for teaching purposes, this 'general' view of the course, as opposed to the trends for individual students, may have more value from a pedagogic point of view. The planning of teaching activities and the alignment of course objectives and assessment methods might be more effectively completed if the general 'state' of student learning patterns is known. It is also hypothesised that the specific results obtained here in terms of the way students learn in the Business Statistics course may be carried over to other such technical and mathematical courses in the sciences.

It has become clear, through the results, that those students who learn according to how they are encouraged to, tend to do far better in terms of final results than those who have no clearly identifiable regulation strategy. Therefore, it is important to decide what kind of knowledge we wish our students to gain from the course. If it is acceptable for students to be learning through repeated example and memorisation of methods, then we should encourage students to learn exactly according to how we direct them to in order to succeed. However, if we wish our

students to gain a deeper understanding of the concepts behind the methods taught, then we need to examine other ways in which to present the course in order that more students some to adopt deep processing strategies and self regulation strategies.

The fact that virtually no students displayed any meaning-directed components of learning, such as deep processing strategies, self regulation strategies, personally interested learning orientations and the conception of learning as the construction of knowledge, may indicate that students, for the most part, are uninterested in the content of the subject. However, some statistics is required for the completion of most commerce degrees. The results of this study thus might convey an important message for programme convenors, particularly those in the commerce faculty, to which the Business Statistics course is a service course. The statistics learnt in this course are often only applicable to the commerce students later on in their studies, particularly during the completion of honours-level projects and theses. It may be that the timing of the course should be revised, in order for students in later years to gain more value from the course rather than having a mere 'pass the exam and get it over and done with' attitude, shown, in part, by the large number of students adopting external regulation strategies.

In terms of students who appear to be eager to learn in co-operation with other students, yet tend to do worse in their final results, it may be necessary to set up a formalised tutorial system as a support network for these students. The results seem to indicate that there are those students who are succeeding and do not appear to find it necessary to work with others, and that there are those who are doing worse in their studies and need the support that other students can provide, although this does not necessarily appear to be helping them in their final results. A supervised group system, with a tutor as facilitator, might therefore be the answer.

It is also important to refer back to the usefulness of the inventory in terms of teaching and the practical application of the inventory in such a course. As has been shown, the inventory has provided useful information about the course in this case, particularly as it relates to being a service course. It may be useful to continue to get students to answer the inventory as each new cohort of students joins the course, in order to monitor any changes in respect of student learning patterns over the years. Also, any changes that might be made to the course, such as perhaps incorporating a supervised tutorial system, could be monitored for the effect they have on student learning patterns.

Future studies involving the ILS, particularly in the realm of scientific courses, could therefore result in important modifications to the inventory for use in this context, and could also reveal important aspects of student learning in science subjects which has not yet been realised. This may result in further changes in the way in which science subjects are taught.

7.6 Concluding comments

This thesis has examined the use of inventories in the study of student learning, and has used one particular inventory, the Inventory of Learning Styles, as a tool in the context of a second year level Business Statistics course at a South African university. The present study was therefore, above all, a case study in student learning and the use of inventories in student learning research.

The findings of the study reveal problems behind the assumptions underlying the inventory, particularly in the context of a science course, yet valuable and important findings about the course in general and the way in which it is taught can be made. The inventory is therefore concluded to have value in terms of pointing out aspects of student leaning which, on the surface, may not be obvious.

It is believed that this thesis has set out the rationale for, the conducting of and the results of what is hoped to be a valuable piece of research. It is also hoped that future research in this field and particularly in this specific context will be forthcoming, and that the present study as well as any future research may result in definite practical implications for teaching.

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APPENDIX A: The Inventory of Learning Styles (adapted for the purposes of the present study)

(It should be noted that the following inventory appeared online on the course website. For the purposes of this appendix, answer options for each question have been removed but were present in the online version of the inventory presented to students.)

Use the following scale in answering questions 1 to 50:
1. I do this seldom or never
2. I do this sometimes
3. I do this regularly
4. I do this often
5. I do this almost always

1. I work through a chapter in the textbook or in the notes item by item and I study each part separately.

2. I repeat the main parts of the subject matter until I know them by heart.

3. I use what I learn from this course in my activities outside my studies.

4. If a textbook or the notes contain extra questions, I work them out completely as soon as I come across them while studying.

5. I study all the subject matter in this course in the same way.

6. I try to combine the subjects that are dealt with separately in this course into one whole.

7. I memorise lists of characteristics and assumptions relevant to certain sections of the material.

8. I realise that it is not clear to me what I have to remember and what I do not have to remember.

9. I make a list of the important facts and learn them by heart.

10. I try to discover the similarities and differences between the different theories that are dealt with in this course.

11. I think that the introductions, objectives, instructions, assignments, notes, projects, tests and extra questions given by the lecturers are very important guidelines for my studying in this course and I make sure I understand all of them.

12. I test my learning only by completing the past test/exam questions, revision questions and assignments provided by the lecturer or notes/textbook.

13. I relate the specific facts of what we are busy learning to the main point of a chapter.

14. I try to interpret events in everyday reality with the help of the knowledge I have acquired in this course.

15. I notice that I have trouble processing large amounts of subject matter.

16. In addition to the syllabus, I study other literature related to the content of this course.

17. I analyse the separate components of a theory or concept that we have been taught step by step.

18. I learn everything exactly as I find it in the notes or textbook.

19. I notice that it is difficult for me to determine whether I have understood the subject matter well enough.

20. To test my learning progress once I have done some studying, I try to formulate the main points in my own words.

21. I pay particular attention to those parts of the course that have practical use.

22. When I am studying, I do not proceed onto another chapter or section until I have understood what I am currently studying completely.

23. When I start reading a new chapter or section, I first think about the best way to go about studying it.

24. I try to see the connection between the topics discussed in different chapters or sections of the notes or textbook.

25. I memorise definitions as literally as possible.

26. I often think that the objectives of the course are too general to be of any help to me in my studies.

27. I do more than I am expected to in the course.

28. I compare my view of a section in the course with the views of the lecturers.

29. If I am able to give a good answer to the questions posed by the lecturer, then I feel that I understand the course material well.

30. When I have difficulty grasping a particular section, I try to analyse why it is difficult for me.

31. I study according to the instructions provided by the lecturers.

32. I memorise the meaning of every concept that is unfamiliar to me.

33. I try to construct an overall picture of the course for myself.

34. I compare the conclusions drawn from different sections in the notes.

35. To test my learning, I try to answer questions about the material that I make up myself.

36. I check whether the conclusions made by the authors of the notes or textbook or by the lecturers, follow the facts on which they are based logically.

37. I study details thoroughly.

38. I realise that I miss having someone (for example, a friend) to fall back on in case of difficulties.

39. I add something to the course material from other sources (for example, the internet, TV, other books).

40. I draw my own conclusions about the material on the basis of what is presented in the course.

41. When doing assignments or projects for the course, I train myself thoroughly in applying the methods dealt with in the course.

42. I analyse the successive steps in a particular theory or argument one by one.

43. To test whether I have mastered the subject matter, I try to think up other examples and problems besides the ones already given in the notes or by the lecturer.

44. I use the instructions or the course objectives given by the lecturer to know exactly what to do in the course.

45. With the help of the theories presented in the course, I find solutions to practical problems.

46. I try to be critical of the interpretations of experts in the field of statistics.

47. When I am studying, I also pursue learning goals that have not been set by the lecturer but by myself.

48. When I am studying a particular topic, I think of cases I know from my own experience that are connected to that topic.

49. If I do not understand the material well, I try to find other books or notes about the topic concerned.

50. If I am able to complete all the extra questions given in the notes, textbook or by the lecturer, I decide that I have a good understanding of the material.

Use the following scale in answering questions 51 to 100:
1. Disagree entirely
2. Disagree for the most part
3. Undecided or do not know
4. Agree for the most part
5. Agree entirely

51. When I have a choice, I choose courses that seem useful to me for my present or future profession.

52. I am study statistics out of sheer interest in the topics that are dealt with.

53. I want to prove to myself that I am capable of doing studies in higher education.

54. I doubt whether statistics is the right subject area for me.

55. I aim at attaining high levels of study achievements.

56. I want to show others that I am capable of successfully doing a higher education programme.

57. I have chosen to study statistics because it prepares me for the type fo work I am interested in.

58. The main goal I pursue in my studies is to pass the exams.

59. I view the choice I have made to enrol in higher education as a challenge.

60. The only aim of my studies is to enrich myself.

61. I have little confidence in my study abilities.

62. For the kind of work I would like to do, I need to have studies in higher education.

63. What I want out of this course is to earn credits towards my degree.

64. I see these studies as sheer relaxation.

65. I study above all to pass the exam for this course.

66. The main goal I pursue in my studies is to prepare myself for a profession.

67. I want to discover my own strengths and weaknesses, the things I am capable and incapable of.

68. What I want to acquire above all through my studies is professional skill.

69. When I have a choice, I choose courses that suit my personal interests.

70. I wonder whether these studies are worth all the effort.

71. I doubt whether this type of education is the right type of education for me.

72. I want to test myself, to see whether I am capable of doing studies in higher education.

73. I am completing my studies because I merely like to learn and to study.

74. I am afraid that these studies are too demanding for me.

75. To me, written proof of having passed an exam represents something of value in itself.

76. The things I learn have to be useful for solving practical problems.

77. I like to be given precise instructions as to how to go about solving a task or doing a project or assignment.

78. When I prepare myself for an exam, I prefer to do so together with other students.

79. To me, learning means trying to approach a problem from many different angles, including aspects which were previously unknown to me.

80. To me, learning is making sure that I can reproduce the facts presented in a course.

81. I should look for relationships within the subject matter without being asked to do this.

82. I like to be encouraged by other students to process the study materials at a particular pace.

83. I should try to apply the theories dealt with in a course to practical situations.

84. The lecturer should encourage me to combine the separate components of the course into a whole.

85. If I have difficulty understanding a topic, I should make an effort to consult other textbooks or notes on the subject.

86. I prefer to do assignments or projects in a group with other students.

87. The lecturer should explain clearly what is important and what is less important for me to know.

88. I have a preference for courses in which a lot of practical applications of the theoretical parts are given.

89. When I have difficulty understanding something, the lecturer should encourage me to find a solution by myself.

90. To me, learning means acquiring knowledge that I can use in everyday life.

91. Good teaching includes giving a lot of extra questions and exercises to test whether I have mastered the subject material.

92. To test my own learning progress, I should try to answer questions about the subject material that I make up myself.

93. The lecturer should encourage me to compare the various theories that are dealt with in the course.

94. I prefer it when I am told exactly what I need to know for the exam.

95. I consider it important to get advice from other students as to how to approach my studies.

96. The teacher should encourage me to check myself whether I have understood the subject material.

97. To me, learning means acquiring knowledge and skills that I can later apply in practice.

98. I should try to think up examples dealing with the subject material on my own.

99. The lecturer should encourage me to reflect on the way I study and how to develop my way of studying.

100. I have a need to work together with other students in my studies.

APPENDIX B: Scoring Key for the Inventory of Learning Styles (adapted from Vermunt (1994) for the purposes of the present study)

COMPONENT 1: Processing Strategies

Scale: Deep processing (10 items)

6. I try to combine the subjects that are dealt with separately in this course into one whole.
10. I try to discover the similarities and differences between the different theories that are dealt with in this course.
13. I relate the specific facts of what we are busy learning to the main point of a chapter..
24. I try to see the connection between the topics discussed in different chapters or sections of the notes or textbook.
28. I compare my view of a section in the course with the views of the lecturers.
33. I try to construct an overall picture of the course for myself.
34. I compare the conclusions drawn from different sections in the notes.
36. I check whether the conclusions made by the authors of the notes or textbook or by the lecturers, follow the facts on which they are based logically.
40. I draw my own conclusions about the material on the basis of what is presented in the course.
46. I try to be critical of the interpretations of experts in the field of statistics.

Scale: Stepwise processing (10 items)

1. I work through a chapter in the textbook or in the notes item by item and I study each part separately.
2. I repeat the main parts of the subject matter until I know them by heart.
7. I memorise lists of characteristics and assumptions relevant to certain sections of the material.
9. I make a list of the important facts and learn them by heart.
17. I analyse the separate components of a theory or concept that we have been taught step by step.
22. When I am studying, I do not proceed onto another chapter or section until I have understood what I am currently studying completely.
25. I memorise definitions as literally as possible.
32. I memorise the meaning of every concept that is unfamiliar to me.
37. I study details thoroughly.
42. I analyse the successive steps in a particular theory or argument one by one.

Scale: Concrete processing (5 items)

3. I use what I learn from this course in my activities outside my studies.
14. I try to interpret events in everyday reality with the help of the knowledge I have acquired in this course.
21. I pay particular attention to those parts of the course that have practical use.
45. With the help of the theories presented in the course, I find solutions to practical problems.
48. When I am studying a particular topic, I think of cases I know from my own experience that are connected to that topic.

COMPONENT 2: Regulation Strategies

Scale: Self regulation (10 items)

16. In addition to the syllabus, I study other literature related to the content of this course.
20. To test my learning progress once I have done some studying, I try to formulate the main points in my own words.
23. When I start reading a new chapter or section, I first think about the best way to go about studying it.
27. I do more than I am expected to in the course.
30. When I have difficulty grasping a particular section, I try to analyse why it is difficult for me.
35. To test my learning, I try to answer questions about the material that I make up myself.
39. I add something to the course material from other sources (for example, the internet, TV, other books).
43. To test whether I have mastered the subject matter, I try to think up other examples and problems besides the ones already given in the notes or by the lecturer.
47. When I am studying, I also pursue learning goals that have not been set by the lecturer but by myself.
49. If I do not understand the material well, I try to find other books or notes about the topic concerned.

Scale: External regulation (10 items)

4. If a textbook or the notes contain extra questions, I work them out completely as soon as I come across them while studying.
5. I study all the subject matter in this course in the same way.
11. I think that the introductions, objectives, instructions, assignments, notes, projects, tests and extra questions given by the lecturers are very important guidelines for my studying in this course and I make sure I understand all of them.
12. I test my learning only by completing the past test/exam questions, revision questions and assignments provided by the lecturer or notes/textbook.
18. I learn everything exactly as I find it in the notes or textbook.
29. If I am able to give a good answer to the questions posed by the lecturer, then I feel that I understand the course material well.
31. I study according to the instructions provided by the lecturers.
41. When doing assignments or projects for the course, I train myself thoroughly in applying the methods dealt with in the course.
44. I use the instructions or the course objectives given by the lecturer to know exactly what to do in the course.
50. If I am able to complete all the extra questions given in the notes, textbook or by the lecturer, I decide that I have a good understanding of the material.

Scale: Lack of regulation (5 items)

8. I realise that it is not clear to me what I have to remember and what I do not have to remember.
15. I notice that I have trouble processing large amounts of subject matter.
19. I notice that it is difficult for me to determine whether I have understood the subject matter well enough.
26. I often think that the objectives of the course are too general to be of any help to me in my studies.
38. I realise that I miss having someone (for example, a friend) to fall back on in case of difficulties.

COMPONENT 3: Learning Orientations

Scale: Personally interested (5 items)

52. I am study statistics out of sheer interest in the topics that are dealt with.
60. The only aim of my studies is to enrich myself.
64. I see these studies as sheer relaxation.
69. When I have a choice, I choose courses that suit my personal interests.
73. I am completing my studies because I merely like to learn and to study.

Scale: Certificate directed (5 items)

55. I aim at attaining high levels of study achievements.
58. The main goal I pursue in my studies is to pass the exams.
63. What I want out of this course is to earn credits towards my degree.
65. I study above all to pass the exam for this course.
75. To me, written proof of having passed an exam represents something of value in itself.

Scale: Self-test directed (5 items)

53. I want to prove to myself that I am capable of doing studies in higher education.
56. I want to show others that I am capable of successfully doing a higher education programme.
59. I view the choice I have made to enrol in higher education as a challenge.
67. I want to discover my own strengths and weaknesses, the things I am capable and incapable of.
72. I want to test myself, to see whether I am capable of doing studies in higher education.

Scale: Vocation directed (5 items)

51. When I have a choice, I choose courses that seem useful to me for my present or future profession.
57. I have chosen to study statistics because it prepares me for the type of work I am interested in.
62. For the kind of work I would like to do, I need to have studies in higher education.
66. The main goal I pursue in my studies is to prepare myself for a profession.
68. What I want to acquire above all through my studies is professional skill.

Scale: Ambivalent (5 items)

54. I doubt whether statistics is the right subject area for me.
61. I have little confidence in my study abilities.
70. I wonder whether these studies are worth all the effort.
71. I doubt whether this type of education is the right type of education for me.
74. I am afraid that these studies are too demanding for me.

COMPONENT 4: Conceptions of Learning

Scale: Construction of knowledge (5 items)

79. To me, learning means trying to approach a problem from many different angles, including aspects which were previously unknown to me.
81. I should look for relationships within the subject matter without being asked to do this.
85. If I have difficulty understanding a topic, I should make an effort to consult other textbooks or notes on the subject.
92. To test my own learning progress, I should try to answer questions about the subject material that I make up myself.
98. I should try to think up examples dealing with the subject material on my own.

Scale: Intake of knowledge (5 items)

77. I like to be given precise instructions as to how to go about solving a task or doing a project or assignment.
80. To me, learning is making sure that I can reproduce the facts presented in a course.
87. The lecturer should explain clearly what is important and what is less important for me to know.
91. Good teaching includes giving a lot of extra questions and exercises to test whether I have mastered the subject material.
94. I prefer it when I am told exactly what I need to know for the exam.

Scale: Use of knowledge (5 items)

76. The things I learn have to be useful for solving practical problems.
83. I should try to apply the theories dealt with in a course to practical situations.
88. I have a preference for courses in which a lot of practical applications of the theoretical parts are given.
90. To me, learning means acquiring knowledge that I can use in everyday life.
97. To me, learning means acquiring knowledge and skills that I can later apply in practice.

Scale: Stimulating education (5 items)

84. The lecturer should encourage me to combine the separate components of the course into a whole.
89. When I have difficulty understanding something, the lecturer should encourage me to find a solution by myself.
93. The lecturer should encourage me to compare the various theories that are dealt with in the course.
96. The teacher should encourage me to check myself whether I have understood the subject material.
99. The lecturer should encourage me to reflect on the way I study and how to develop my way of studying.

Scale: Co-operation (5 items)

78. When I prepare myself for an exam, I prefer to do so together with other students.
82. I like to be encouraged by other students to process the study materials at a particular pace.
86. I prefer to do assignments or projects in a group with other students.
95. I consider it important to get advice from other students as to how to approach my studies.
100. I have a need to work together with other students in my studies.

APPENDIX C: Summary of ILS scales and associated learning patterns

Vermunt's (1998) Inventory of Learning Styles (ILS)

Parts and scales of the ILS:	Description:	Learning pattern: Meaning-directed	Reproduction-directed	Application-directed	Undirected
1 ***Processing strategies***					
Deep processing					
relating & structuring	making connections between subjects & forming an overall "big picture"	x			
critical processing	making own conclusions & deductions & being critical of those of others	x			
Stepwise processing					
memorising & rehearsing	rote learning & memorising of material		x		
analysing	analysing every detail of subject material, bit by bit		x		
Concrete processing	learning by applying material through concrete experience			x	
2 ***Regulation strategies***					
Self regulation					
learning process & results	planned learning/studying, monitoring of individual progress & testing	x			
learning content	learning from literature & other sources aside from those recommended	x			
External regulation					
learning process	learning according to instructions given by others, or provided by material		x		
learning results	using external means such as past papers to test knowledge		x		
Lack of regulation	realising that own study methods are failing				x
3 ***Conceptions of learning***					
Construction of knowledge	learning seen as forming of own opinions, seen as responsibility of student	x			
Intake of knowledge	learning seen as taking in knowledge provided, mainly by memorising & reproducing, other learning activities are responsibility of teachers		x		
Use of knowledge	learning seen as gaining knowledge that can be practically used and applied, responsibility of both students & teachers			x	
Stimulating education	learning seen as responsibility of student, but teachers should stimulate students to learn				x
Co-operative learning	learning seen as most effective when done with others				x
4 ***Learning Orientations***					
Personally interested	studying out of personal interest & for personal gain	x			
certificate-orientated	studying to pass exams, obtain degree, certificate or some qualification		x		
self-test orientated	studying to prove to self & others that one is able to do it		x		
vocation-orientated	studying to acquire professional skills (needed to obtain a job)			x	
ambivalent	usure & uncertain towards studies, own abilities, choice of discipline				x

APPENDIX D: Factor analysis results

Eigenvalues (ILS)				
Value	Eigenvalues (ILS)	% Total Variance	Cumulative Eigenvalue	Cumulative %
1	4.516	28.225	4.516	23.225
2	2.508	15.673	7.024	43.898
3	1.407	8.795	8.431	52.693
4	1.222	7.638	9.653	60.331

Factor loadings (Varimax normalized)				
Variable	Factor 1	Factor 2	Factor 3	Factor 4
Deep	***0.830***	-0.102	0.272	-0.051
Stepwise	***0.662***	0.496	0.035	-0.151
Concrete	***0.768***	-0.114	0.333	0.006
Self reg	***0.835***	-0.005	0.220	-0.034
Ext reg	0.499	***0.556***	0.021	0.003
Lack Reg	0.033	0.228	-0.275	***0.712***
Construction	0.178	-0.145	***0.621***	-0.252
Intake	-0.208	***0.568***	0.117	0.355
Use	-0.076	0.292	0.391	0.405
Stim Ed	0.204	***0.517***	***0.528***	-0.265
Co-operative	-0.137	0.158	-0.317	***0.744***
Personal	0.406	0.067	***0.665***	-0.033
Certificate	-0.071	***0.715***	0.135	0.199
Self-test	0.188	0.300	***0.649***	-0.014
Vocation	0.206	0.185	***0.589***	0.094
Ambivalent	0.037	-0.151	0.357	***0.651***

APPENDIX E: Summary of student responses per question

Question			Frequency				
No.	N	-	1	2	3	4	5
1	258	0	47	72	54	43	42
2	258	0	51	80	57	42	28
3	258	0	85	123	30	9	11
4	258	0	91	90	35	24	18
5	258	1	16	48	59	64	70
6	258	1	70	102	46	28	11
7	258	1	19	64	62	56	56
8	258	3	74	91	44	34	12
9	258	2	41	81	48	49	37
10	258	2	48	73	56	43	36
11	258	2	7	42	52	85	70
12	258	2	9	31	50	60	106
13	258	2	43	87	63	38	25
14	258	2	99	82	37	24	14
15	258	2	67	97	44	33	15
16	258	3	214	24	10	4	3
17	258	3	32	77	59	49	38
18	258	3	9	57	59	88	42
19	258	3	66	79	50	42	18
20	258	3	47	59	58	51	40
21	258	3	39	77	55	54	30
22	258	3	27	81	48	51	48
23	258	3	74	65	47	34	35
24	258	3	25	87	66	45	32
25	258	3	17	81	53	54	50
26	258	3	80	105	31	26	13
27	258	3	122	91	23	13	6
28	258	3	123	70	36	15	11
29	258	3	27	64	56	63	45
30	258	3	54	81	54	41	25
31	258	3	32	72	66	54	31
32	258	3	43	85	64	39	24
33	258	3	54	80	49	38	34
34	258	3	67	85	51	31	21
35	258	4	149	45	26	21	13
36	258	4	68	74	48	36	28
37	258	4	12	69	68	67	38
38	258	4	70	77	27	38	42
39	258	4	186	43	15	3	7
40	258	4	49	92	67	31	15
41	258	4	16	60	77	67	34
42	258	4	20	54	79	64	37
43	258	4	140	54	26	18	16
44	258	4	22	51	65	63	53
45	258	4	77	92	39	30	16
46	258	4	113	79	32	19	11
47	258	4	73	67	44	37	33
48	258	4	74	100	39	24	17
49	258	5	98	74	35	26	20
50	258	5	16	32	56	66	83

Question			Frequency				
No.	N	-	1	2	3	4	5
51	258	6	3	8	24	106	111
52	258	6	51	70	43	75	13
53	258	6	22	21	26	86	97
54	258	6	51	75	51	46	29
55	258	6	2	17	33	85	115
56	258	6	24	35	22	73	98
57	258	6	30	50	49	81	42
58	258	6	29	66	22	85	50
59	258	6	9	21	25	118	79
60	258	6	21	62	40	108	21
61	258	6	118	73	25	32	4
62	258	6	4	11	16	38	183
63	258	6	15	57	27	94	59
64	258	6	132	92	20	6	2
65	258	6	13	52	24	101	62
66	258	7	3	14	17	117	100
67	258	7	2	10	32	100	107
68	258	7	0	15	26	123	87
69	258	7	1	12	29	122	87
70	258	7	52	75	46	56	22
71	258	7	85	95	38	24	9
72	258	8	37	45	30	89	49
73	258	7	66	109	35	36	5
74	258	7	53	97	39	53	9
75	258	7	11	27	37	111	65
76	258	7	2	25	21	137	66
77	258	7	7	19	25	104	96
78	258	7	66	87	25	52	21
79	258	7	6	29	51	112	53
80	258	7	19	77	30	97	28
81	258	7	3	24	60	120	44
82	258	7	31	62	54	81	23
83	258	7	4	13	33	136	65
84	258	7	4	16	49	115	67
85	258	8	3	15	21	108	103
86	258	7	45	65	30	72	39
87	258	7	2	8	16	103	122
88	258	8	0	17	54	90	89
89	258	7	20	68	65	79	19
90	258	9	0	11	13	122	103
91	258	7	2	23	29	120	77
92	258	7	22	64	61	79	25
93	258	7	4	12	66	123	46
94	258	7	2	11	12	55	171
95	258	7	22	47	52	104	26
96	258	7	4	17	42	125	63
97	258	7	2	7	11	99	132
98	258	7	25	55	75	74	22
99	258	8	13	26	51	107	53
100	258	6	42	76	44	68	22

APPENDIX F: Between-question correlation matrices

Deep processing

	6	*10*	*13*	*24*	*28*	*33*	*34*	*36*	*40*	*46*
6	1.00									
10	0.36	1.00								
13	0.26	0.29	1.00							
24	0.44	0.40	0.49	1.00						
28	0.21	0.32	0.26	0.27	1.00					
33	0.30	0.38	0.42	0.47	0.28	1.00				
34	0.34	0.41	0.41	0.45	0.31	0.51	1.00			
36	0.13	0.15	0.24	0.18	0.21	0.17	0.31	1.00		
40	0.25	0.34	0.22	0.28	0.27	0.31	0.33	0.34	1.00	
46	0.25	0.20	0.19	0.23	0.27	0.24	0.26	0.32	0.26	1.00

Stepwise processing

	1	*2*	*7*	*9*	*17*	*22*	*25*	*32*	*37*	*42*
1	1.00									
2	0.31	1.00								
7	0.23	0.33	1.00							
9	***0.05***	0.43	0.38	1.00						
17	0.28	0.41	0.29	0.22	1.00					
22	0.22	0.19	***0.08***	0.15	0.27	1.00				
25	***0.07***	0.29	0.39	0.34	0.28	0.20	1.00			
32	***0.08***	0.32	0.32	0.34	0.18	0.13	0.36	1.00		
37	0.17	0.26	0.24	0.23	0.39	0.17	0.19	0.22	1.00	
42	0.22	0.25	0.19	0.20	0.38	0.23	0.20	0.17	0.36	1.00

Concrete processing

	3	*14*	*21*	*45*	*48*
3	1.00				
14	0.58	1.00			
21	0.16	0.34	1.00		
45	0.35	0.50	0.32	1.00	
48	0.39	0.50	0.31	0.37	1.00

Self regulation

	16	*20*	*23*	*27*	*30*	*35*	*39*	*43*	*47*	*49*
16	1.00									
20	0.21	1.00								
23	***0.11***	0.35	1.00							
27	0.33	***0.12***	0.23	1.00						
30	***0.06***	0.20	0.36	0.21	1.00					
35	0.31	0.37	0.26	0.25	0.20	1.00				
39	0.36	0.17	***0.07***	0.22	***0.03***	0.33	1.00			
43	0.31	0.27	0.29	0.32	0.25	0.58	0.31	1.00		
47	0.20	0.16	0.34	0.16	0.25	0.24	0.12	0.26	1.00	
49	0.29	0.21	0.18	0.18	0.22	0.21	0.29	0.28	0.35	1.00

External regulation

	4	*5*	*11*	*12*	*18*	*29*	*31*	*41*	*44*	*50*
4	1.00									
5	0.14	1.00								
11	0.25	***0.09***	1.00							
12	0.19	0.15	0.26	1.00						
18	***0.02***	0.22	***-0.04***	0.13	1.00					
29	0.12	0.15	***-0.02***	***0.11***	***0.05***	1.00				
31	***0.06***	***0.05***	***-0.04***	***0.02***	0.18	0.15	1.00			
41	0.16	***0.09***	0.28	0.24	***-0.04***	0.19	0.17	1.00		
44	***0.11***	***0.05***	0.26	0.16	0.12	***0.11***	0.31	0.28	1.00	
50	0.14	***0.08***	***0.06***	0.13	0.14	0.29	***0.08***	0.18	0.12	1.00

Lack of regulation

	8	*15*	*19*	*26*	*38*
8	1.00				
15	0.39	1.00			
19	0.37	0.46	1.00		
26	0.17	0.19	0.22	1.00	
38	0.26	0.24	0.21	0.12	1.00

Personally interested orientation

	52	*60*	*64*	*69*	*73*
52	1.00				
60	***0.12***	1.00			
64	0.21	0.17	1.00		
69	***0.08***	***0.03***	***0.07***	1.00	
73	0.16	0.14	***0.10***	***0.02***	1.00

Certificate directed orientation

	55	*58*	*63*	*65*	*75*
55	1.00				
58	***-0.32***	1.00			
63	***-0.16***	0.20	1.00		
65	***-0.18***	0.50	0.28	1.00	
75	***0.08***	***0.10***	***0.05***	0.20	1.00

Self-test directed orientation

	53	*56*	*59*	*67*	*72*
53	1.00				
56	0.53	1.00			
59	0.26	0.15	1.00		
67	0.13	***0.10***	0.18	1.00	
72	0.54	0.44	0.31	0.20	1.00

Vocation directed orientation

	51	*57*	*62*	*66*	*68*
51	1.00				
57	0.17	1.00			
62	0.24	0.16	1.00		
66	0.13	0.20	0.19	1.00	
68	0.13	0.15	0.17	0.48	1.00

Ambivalent orientation

	54	*61*	*70*	*71*	*74*
54	1.00				
61	0.22	1.00			
70	0.26	0.36	1.00		
71	0.20	0.42	0.39	1.00	
74	***0.07***	0.47	0.31	0.38	1.00

Construction of knowledge

	79	*81*	*85*	*92*	*98*
79	1.00				
81	0.24	1.00			
85	0.21	0.29	1.00		
92	0.34	0.21	0.25	1.00	
98	0.32	0.31	0.27	0.56	1.00

Intake of knowledge

	77	*80*	*87*	*91*	*94*
77	1.00				
80	0.24	1.00			
87	0.31	0.14	1.00		
91	***0.03***	0.19	0.13	1.00	
94	0.27	0.19	0.45	0.15	1.00

Use of knowledge

	76	*83*	*88*	*90*	*97*
76	1.00				
83	0.37	1.00			
88	0.22	0.22	1.00		
90	0.30	0.24	0.15	1.00	
97	0.33	0.26	0.28	0.49	1.00

Stimulating Education

	84	*89*	*93*	*96*	*99*
84	1.00				
89	0.14	1.00			
93	0.44	0.26	1.00		
96	0.34	0.21	0.40	1.00	
99	0.27	0.24	0.38	0.47	1.00

Co-operation

	78	*82*	*86*	*95*	*100*
78	1.00				
82	0.21	1.00			
86	0.49	0.20	1.00		
95	0.31	0.35	0.32	1.00	
100	0.58	0.32	0.59	0.38	1.00

APPENDIX G: t-test results

t-Test: Two-Sample Assuming Equal Variances
no evident processing strategy vs stepwise processing

	none	*stepwise*
Mean	68.71	70.96
Variance	151.82	209.15
Observations	161	60
Pooled Variance	167.27	
Hypothesized Mean Difference	0	
df	219	
t Stat	-1.15	
P(T<=t) one-tail	0.13	
t Critical one-tail	1.65	
P(T<=t) two-tail	0.25	
t Critical two-tail	1.97	

t-Test: Two-Sample Assuming Equal Variances
no evident regulation strategy vs external regulation

	none	*external*
Mean	67.38	73.21
Variance	180.65	155.81
Observations	83	85
Pooled Variance	168.08	
Hypothesized Mean Difference	0	
df	166	
t Stat	-2.91	
P(T<=t) one-tail	0.002	
t Critical one-tail	1.65	
P(T<=t) two-tail	0.004	
t Critical two-tail	1.97	