8-1998

Databases and Student Learning: A Multilevel Analysis of the Use of Databases in the Classroom

Peter Beamish
peter.beamish@avondale.edu.au

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Peter James Beamish
B.Ed.(Sc.) M.Ed.Stud.

Submitted to the Faculty of Education,
The University of Newcastle,
in fulfilment of the requirements for
the award of the degree of Doctor of Philosophy.

August, 1998.

I hereby certify that the work embodied in this thesis is the result of original research and has not been submitted for a higher degree to any other University or Institution.

PETER JAMES BEAMISH

DEDICATION

TO MY PARENTS,
WHO FROM MY EARLIEST YEARS HAVE ALWAYS TAKEN GREAT INTEREST
IN EVERY STEP OF MY ACADEMIC JOURNEY.

ACKNOWLEDGEMENTS

I wish to thank the people that have helped me and consequently contributed to this research project and thesis.

First and foremost I wish to acknowledge my debt to Professor Sid Bourke from the University of Newcastle for his help in conducting this research and the preparation of this thesis. As my academic supervisor I have appreciated Sid's expertise, enthusiasm for educational research, patience, and good humour. I thank him for the support he has given me and I value the friendship that we have formed.

I also wish to thank Dr. Wing Au from the University of South Australia. During the first part of this research project Wing supervised my research efforts and, although he moved interstate, has continued to share his knowledge and expertise with me. I thank him for his friendship, encouragement, and academic guidance.

I would like to thank Dr. Max Smith from the New South Wales Department of Education for his advice and friendship. Max willingly gave of his time to advise me on the methods of analyses employed in this thesis and I benefited from this advice.

During this research project I was employed as an Educational Computing lecturer at Avondale College. I wish to thank the administration and staff of the College for their interest and support during my studies. In particular, I wish to thank the staff of the Faculty of Mathematics and Computing for their help, assistance, and for the considerable support they have provided over the years.

I wish to thank the schools, teachers, and students whose participation made this study possible. I also wish to thank Zena Beamish and Sallyanne Dehn for their help in proof reading this thesis.

Finally, I want to thank my family for their patience and support during the lengthy process of conducting a research project and preparing a dissertation. In particular, my wife Debra for the consideration and support she has provided during the years of the study, and my children, Callan and Tarryn, for their patience while daddy was busy in his office. Also, I wish to thank my parents for their support and the many hours of baby sitting that helped to bring this study to fruition.

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Abstract

This study investigated the use of computerised databases to enhance student learning in the secondary school classroom, and included student factors and classroom processes that influenced their success. Students worked through a course in which they used computers and database management software to solve problems requiring them to work with information. Based on a constructivist pedagogy the course aimed to help students construct knowledge, develop skills in information processing, develop higher order thinking skills, and develop positive attitudes to computers.

Data were collected from 541 students in 25 classrooms at 12 schools in New South Wales using a series of tests, questionnaires and classroom variables. Multilevel regression analysis was used to test hypothesised causal model linking presage, process and product variables.

Students successfully learned to use databases during the course, acquiring content knowledge of the databases and increasing their information processing skills. Students reported positive attitudes to computers and these attitudes directly influenced their achievement. The latter served to emphasise the importance of developing appropriate attitudes in computer classroom learning activities.

A number of other factors were found to influence the success of database activities. Gender and student approaches to learning influenced both cognitive and attitudinal outcomes directly. Students' previous computer experiences were found to influence approaches to learning, information processing ability, and attitudes to computers.

Several classroom contextual variables were also found to be important, including peer interaction, time on task and the type of database software used. Other teaching methods were of interest because of their negative or lack of influence on learning outcomes. The use of a heuristic was found to have a negative effect, while direct instruction of strategies and teacher modelling of strategies failed to affect learning outcomes.

Overall, most students used databases to collect and analyse data successfully. Most teachers were pleasantly surprised at the level of work completed by their students during the database course.

Chapter 1

An Introduction to the Study

Introduction

This study investigated the use of computerised databases to enhance student learning in the secondary school classroom. Students completed a course in which they used computers and database management software to solve problems that required them to work with information. The present study investigated the learning outcomes associated with classroom database use and the student factors and classroom processes that influenced the success of these learning activities.

This chapter sets out the background to the study, an overview of the study, research objectives, the significance of the study, the definition of key terms, and the structure of the thesis.

Background to the Study

The number of computers in schools continues to increase. Pelgrum and Plomp (1993), in a study of computer use in education across a number of countries, concluded that the use of computers in education is increasing. All countries in their study reported increased computer use in schools although to varying degrees. This increased use has been accompanied by a world-wide trend toward the 'tool' use of computers in classrooms (Fitzgerald, Hattie, & Hughes, 1985; Pelgrum & Plomp, 1993). 'Tools' are sophisticated content-free applications and are used to perform a wide variety of classroom tasks. For example, as a tool the computer can be used as a calculator in Mathematics, a spreadsheet to record the results of a scientific experiment, a database in the teaching of History, a word processor in English, as well as many other uses.

Databases are one such content-free application (tool) that educators hope to use to achieve a number of desirable outcomes. As western society consolidates its transition to an 'information society', the use of information within this society continues to increase (Maor, 1993). The vital knowledge required by students is how to access stored information as and when required, and how to interpret and manipulate the data they retrieve (Riding & Chambers, 1993). An important skill for adult life is the ability to work with information, the development of which is best started in school years (Langhorne, 1989; Maor, 1993). The use of databases may help students develop the information skills necessary for independent lifelong learning, future employment, and active participation in today's information society.

Secondly, although the ability to access information is important, studies have identified that experts in a domain have a highly developed knowledge base and utilise higher order thinking skills, including metacognitive skills (Woods, 1988). The use of databases may help students acquire knowledge within a domain and consequently facilitate the development of higher order thinking skills as they use databases to collect, organise, select, and manipulate information.

Finally, the use of databases may encourage students to develop positive attitudes to computers, learning, and classroom activities. Such attitudes are important as they influence student acceptance of information technologies and student behaviour with respect to computers. As students spend a significant portion of their lives at school, attitudes to themselves and to their work are important in their own right. However, student attitudes are also considered important as they may influence student achievement.

The above outcomes do not occur by chance but are the result of the learning environment in which databases are used. This includes the students, teacher, and computers combining together to facilitate the construction of knowledge, the development of higher order thinking, and the development of positive attitudes to computers. Teachers enhance these outcomes through the use of appropriate classroom practices and pedagogy. Particularly during problem solving activities that use information, teachers need to provide an environment that encourages the development of information processing and metacognitive skills. The research literature outlines a number of teaching strategies that may help students with the construction of knowledge and the development of skills during database activities.

Overview of the Study

This study investigated student learning through the use of databases in the classroom. In particular, the study focused on the outcomes that result from the classroom use of databases. These included student knowledge of databases, the content knowledge students acquire from working with the various databases in the course developed for this study, student information processing skills, and student attitudes to computers. The study considered the various classroom and student factors that influence these outcomes and how these outcomes may be related. The Year 9 subject of Computing Studies was selected as the vehicle for the study because of the access it enjoys to school computing facilities. Also, as the Computing Studies subject contains a unit on Information Systems, the intervention course used in the study fitted within the existing curriculum.

The study consisted of three stages. The initial stage involved the development of a database course which taught students how to use database software and engaged them in a number of problem solving activities requiring the use of databases to work with information. The course culminated in students conducting a research project in which the use of databases played a central role. It was designed to run for ten weeks and to provide students with a cognitively rich learning environment which encouraged them to engage in metacognitive activity.

The second stage of the study saw the trialing of the database course and the development of the testing instruments. A total of 278 students in nine classes at six schools in the Hunter Region undertook the draft database course. Tests of Information Processing and Database Content Knowledge were developed, and the Flexibility in Learning scales were refined.

The final stage of the study involved collecting and analysing data from a sample of 541 students in 25 classes at 12 schools in the Hunter Region as they worked with databases. During this final stage, in addition to administering the tests and questionnaires, each of the classrooms was observed to collect data on the classroom process variables important to the study.

The focus throughout the study was on student use of databases, the relationships between the outcomes of this use, and the nature of teaching and learning activity in

Year 9 Computing Studies classrooms. However, data collected from studies of educational practice often have a nested structure due to the different levels found within school systems. Students are grouped in classes and these classes are grouped within schools. Analysing these complex associations required an approach that could accommodate complex patterns of association between variables at the same, and also at different levels of a multilevel structure.

Smith (1996: 108-132) outlines an analytical approach that involves the development of theory-based networks of association linking variables of interest. The patterns of association are expressed in the form of path diagrams which are analysed using structural equation modelling techniques as heuristic devices to identify and decompose the patterns of association. Structured equation modelling provides a means of translating theoretical relationships into mathematical expressions that can be used to estimate associations between the variables (Bourke, 1984: 30; Keeves, 1988: 724; Williams, 1988; Smith, 1996: 110).

After Smith (1996), a multilevel model was established to investigate hypothesised causal relationships between factors associated with student use of databases in the classroom. The study then proceeded to test to see if the General Model for Analysis was consistent with the data. The two stage analysis used in this study incorporated both LISREL8 (Joreskog & Sorbom, 1993a) measurement models and multilevel analysis using MLn (Rasbash & Woodhouse, 1995). The first stage involved the development of LISREL8 one-factor congeneric measurement models to provide optimally weighted composites from multiple indicators of latent constructs. The measurement models were used in stage two of the analysis where the composites formed in stage one were passed to MLn multilevel models to establish the significance of multilevel effects.

Research Objectives

The study described student learning within a computerised environment by using the 3P model (Biggs & Moore, 1993: 448) of the teaching/learning system. This model considers that learning in the classroom takes place within a dynamic system and that a wide range of factors may influence this system. The model contains three phases:

presage, process, and product. Presage factors are those aspects of student and teaching contexts that exist prior to the immediate action in the classroom. These influence process factors, the teaching-learning processes in the classroom, and these in turn influence the product factors, usually thought of in terms of student achievement.

Using this framework, the current study sought to meet two main research objectives. The first was to investigate the outcomes (product factors) associated with the classroom use of databases and the nature of the relationships between these outcome variables. The second was to investigate the relationships between various background- (presage), process-, and outcome- (product) variables associated with the classroom use of computerised databases. In particular, the research addressed issues concerned with the use of databases in the classroom to facilitate student learning, the outcomes of classroom database use, the effect of presage and process factors on these outcome factors, and the multilevel effects in the data. The specific research questions that the study addressed are outlined in Chapter 5.

A general model for analysis was developed to illustrate the relationships posited to exist between the various presage, process, and product factors included in the study. The putative causal relationships presented in this model linking classroom- and student-level variables were tested using two sets of analyses. The first investigated the relationships between the various classroom- and student-level variables and the student-level outcome variables. The second investigated the relationships between the student-level outcome variables themselves. The analyses were undertaken using multilevel statistical techniques which take into account the clustering of students within classrooms, and classrooms within schools (Goldstein, 1995). This allowed the relationships of interest to be treated within an analytical framework representing as close as currently possible the ecological reality of the classroom.

Significance of the Study

Microcomputers became widely available in schools in Australia in the 1980's. During this time, the advocates of the use of computer technologies made many claims about the advantages of using computer technologies in education. As we near the year 2000 few of these proposed advantages have been realised. The 1990's have seen a reassessment and a re-evaluation of the use of computers in schools. Many educators realise that computers can help students to learn. This does not take place as a matter of course, but rather only when computers are used with careful planning, integrated with other learning experiences, and in the appropriate context.

This study examined student learning using databases in the classroom. It explored the nature of the outcomes of database activities and the relationships between these outcomes. It has also explored both classroom- and student-level factors that influence these learning outcomes and explored the contexts that best support learning in the classroom using computer technologies. In particular, the database course used in the study was designed to provide students with a rich cognitive environment in which to use computers. It sought to provide a learning context that facilitated the development of both cognitive and metacognitive knowledge through the use of situated learning, expert practice, intrinsic motivation, and cooperative learning (Collins, Brown, & Newman, 1989). It is hoped that by gaining a better understanding of the role computers can play in the learning process, and the contexts in which they can be most effectively used, teachers, students, and technology can develop a system in which student learning may be optimised.

Definition of Key Terms

In a developing field, the meaning of commonly used terms frequently differs between users and occasions. To avoid confusion, before proceeding to consider the review of the literature, some of the key terms used throughout the study are defined and clarified.

Database Knowledge

Database Knowledge refers to the knowledge that students have of databases. That is, the way databases are structured, the way that they work, and the operations that they are used to perform. Some of this knowledge is global in nature while some is software specific.

Database Content Knowledge

Database Content Knowledge refers to the knowledge that students acquire of the data and information that is stored within the database. It does not refer to the way that the database operates, but to the data stored within it. Database content knowledge may exist at a number of levels of abstraction. Kirby's (1991) notion of operational levels in text processing may provide a framework for describing levels in database content knowledge. Not only do students work with individual pieces of data, but they synthesise ideas, main ideas, and themes. These levels may form a basis for differentiating levels of understanding.

Information Processing Skills

Information Processing Skills refer to the skills that students use when they work with information. These include the skills identified by White (1985) of organising information, determining if information is relevant to the problem at hand, and determining if there is sufficient information to solve a given problem. The current study adds to these skills by including measures of hypothesis formation, and interpretation of data.

Attitudes to Computers

The study defined student attitudes to computers in terms of confidence in using computers, and liking for computers. These scales were originally developed by Loyd and Gressard (1984) along with a subscale on anxiety toward computers. Working with Year 9 students in Australia, Beamish (1988) modified these attitude scales to include confidence in using computers and liking for computers only. It is the modified scales that are used in this study.

Approaches to Learning

Approaches to Learning refer to the confluence of student motives for learning and the various strategies they use to engage in learning. Approaches are defined as being either deep, surface, or achieving, or a combinations of these (Biggs, 1987).

Flexibility in Learning

Flexibility in Learning was used in the study to describe the executive cognitive mechanisms that students use during learning. Students may be described as being adaptive, inflexible, or irresolute as they engage in self-regulation (Cantwell, 1994).

Computer Experience

Computer experience refers to the body of background experiences that students have acquired as they work with computers. These experiences occur at home, at school, and at other places such as parents' work, or at the homes of their friends. They range across the tool, tutor, and tutee uses of computers and include the playing of computer games.

Structure of the Thesis

This thesis has been divided into 10 chapters. The current chapter provides the background to the study and identifies the key aspects of student database use under investigation. Chapter 2 provides a review of the literature on the use of computers, and specifically databases, in the classroom. The review discusses the background to the use of computers in education, identifies the benefits of database use, and uses the research literature to test the claims made about database use in the classroom.

Chapter 3 discusses the factors that surround the effective use of databases in the classroom by introducing the 3P model and reviewing the literature on the various presage factors that may influence both the use of databases in the classroom and the learning outcomes associated with database use. Chapter 4 extends this discussion by considering the process and product factors associated with database use.

Chapter 5 elaborates on the conceptual framework of the study and then introduces the general model for analysis. The constructs included in the model are defined and the specific research questions investigated in the study are set out. Chapter 6 provides details of the research methodology. This includes an overview of the research design, details of the development and trialing of the database course and the development of the testing instruments. The final sections of Chapter 6 discuss the main study and provide details of the testing instruments used. This chapter finishes with a discussion of the analytical framework and analysis of the study, including details of the multilevel statistical techniques used in the analysis.

Chapter 7 provides descriptions of the student and classroom variables and constructs used in the analysis. This chapter is divided into two sections. Section one describes the student variables and constructs while section two provides details of the classroom variables and constructs.

The multilevel analysis is reported in three stages in Chapter 8. Stage 1 investigates the levels of school- and class-effects in the data. Stage 2 considers the relationships between the various student- and classroom-level variables with the student-level outcome variables through the development of a multilevel structural equation model. Stage 3 examines the relationships between the student-level outcome constructs through a multivariate-multilevel structural equation model.

Chapter 9 provides a summation of the research findings of the previous two chapters through responses to the specific research questions. Chapter 10 provides an overview of the findings of the study, discusses the limitations of the study and the implications of the research findings. It concludes with suggestions for further research.

Chapter 2

Computers in Education

Introduction

As a result of advances in computer technology, and particularly the development of low cost personal machines, computers have found their way into nearly every aspect of our daily lives. They have served to empower humans, enabling man and machine to form a system that can perform tasks at a speed that humans would have thought nearly impossible only a few years ago. One consequence of this has been the transformation of society into an information society that is based on a global knowledge economy (Dertouzos, 1997: 5). Within this society, communication technologies for transmitting information combine with computer systems for processing it to affect our culture, pace of life, and what we do for a living (Wriston, 1992: 3). Competitive advantage in this environment comes from the ability to move from data to knowledge, then onto insight/foresight, and finally to wisdom (Tinkler, Lepani, & Mitchell, 1996: 74). To accomplish this, participants need to be information literate. This literacy requires information collecting and analysis skills, management skills, systems thinking, metacognition skills, and the ability to use information technologies (van Weert, 1995). Educators may encourage their students to acquire these skills by the use of computer technologies in the classroom.

Background to the Use of Computers in the Classroom

Although computers have been available for some time, the logistical factors of cost and size delayed their introduction to the mainstream school classroom until the 1970's. From this time on, schools started using computers for a variety of reasons. It was expected that, by using them, the quality of education would be improved. Also, students would need to know how to use computers to be able to function properly within a society that was making increased use of computer technologies (Pelgrum & Plomp, 1993). These expectations, heightened by the aggressive marketing strategies of some computer companies, lacked specificity and as a result, the educational goals for the use of computers in schools were not clear.

By 1976, computers were in wide use in tertiary institutions, and all states of Australia were supporting the development of computer applications in secondary schools. Yet there appeared to be no real computer related activity in primary schools (Wearing, Carss & Fitzgerald, 1976). The use of computers in Australian schools, however, soon increased dramatically. By the mid-eighties, Fitzgerald, Hattie, and Hughes (1985) reported that 98 per cent of secondary schools and 57 per cent of primary schools were conducting computer activities in their schools. This was similar to the world-wide trend in the use of computers in schools. Pelgrum and Plomp (1993) in a study of 22 countries (the sample did not include Australia) reported that computers were generally introduced into secondary schools and then more slowly into primary schools. All countries in their study were using computers in schools to varying degrees with the main reason given for their use being 'to provide experience for the future'.

In high schools, computers tended to be located in computer laboratories, while in primary schools they were more likely to be located within the normal classroom (Pelgrum & Plomp, 1993). Despite their location, computers were found to be used as an add-on to the existing curriculum rather than an integral part of it. Only 15 per cent of teachers used computers within the schools and the number of teachers who integrated computers to a substantial extent into the curriculum was even smaller at three per cent. Factors associated with the curriculum use of computers included the availability of computers in the classroom rather than in a specialised location, and the availability of hardware and educational tool software (Pelgrum & Plomp, 1993). The lack of curriculum integration was also found to be associated with how useful teachers perceived computers to be. Research in the area of computers in education, had not provided 'large scale' information that provided evidence that student learning was enhanced when they worked with computers. Although educational practitioners in most countries reported very positive attitudes about the educational impact of computers, many teachers were not convinced that computers were worth the effort (Reinen, Pelgrum & Plomp, 1995).

The 1990's have seen an increase in interest in the use of computers in the classroom. Indications of this are found in the increasing number of computers in schools accompanied by an increase in the number of journals concerned with the use of computers in schools (MacKinnon & Bush, 1993). It has also seen a period of re-assessment of the use of computers. Collis (1995) illustrates this using the metaphor of a spiral to relate four phases of research activity. From the top these phases include a describe/understand phase, a design/pilot phase, a hypothesis testing phase, and a reflective meta-analysis phase that returns to the top of the spiral. All of the papers presented at the 1979 IFIP WG3.3 Conference (Lewis & Tagg, 1980) could be categorised as level 1 (describe/understand). By 1993, 10 of the 16 chapters containing papers presented at the IFIP WG3.3 Conference (Lewis & Mendelsohn, 1994) could be categorised as level 4 (reflective meta-analysis). Few of the 1993 studies reported the direct use of computers in classrooms, rather they reflected and reassessed the use of computers in education. The educational computing field had become more theoretical and reflective (Collis, 1995).

The total number of computers continues to increase in Australian schools. The Financial Review (3 February, 1995) reported that there was, on average, one computer for every 15.5 students in Australian schools. Governments are committed to increases in the use of computers in schools. For example, the N.S.W. State Government has committed itself to establishing banks of lap-top computers, providing training and syllabuses, using computers to enhance the teaching of each subject, and linking all schools to the 'information superhighway'. In particular, priorities in the use of computers in education in N.S.W. for the years 1995 to 1999 include:

- every student should learn to touch type on a keyboard by Year 7.
- a bank of lap-top computers will be established in each school so that senior school students can borrow them for home study.
- every teacher will receive an initial 30 hours training in the educational use of computers, designed for their subject.
- every syllabus will state how computers can enhance the teaching and learning of each subject.
- computers will not take over the classroom. Teachers will remain in charge and use computers as a teaching tool for the whole class.
- funding for computers will be made available for most disadvantaged non-government schools.
- The computer/pupil ratio in primary schools will be reduced to 1:14.
- Every school will be connected to the superhighway to link schools to the information of the world (under supervision).
- all new teachers in government schools will be computer literate and have the proven capacity to use computers in classrooms.

- within each high school, a teacher will be appointed as a co-ordinator of the use of computers.
- after-hours computer classes will be established for students, teachers, and parents who want to increase their access to technology.
- community access to schools' computer courses will be encouraged, including the provision of software rental libraries, and the renting out of computer time not required by the school.

(Tinkler et al., 1996: 10)

Although governments are trying to increase the use of technology in schools, computers are still not being used extensively throughout the curriculum. Barriers to computer integration include the number of computers available for use, inadequate financial support, and not enough time for teachers to develop use of computers in their teaching (Sherwood & Buchanan, 1993). The lack of integration of computers into the existing curricula, is the most challenging factor in determining the future use of computers in schools (Pelgrum & Plomp, 1993).

Trends in Computer Use Throughout the Curriculum

An important consideration for educators is how computers can be used in the classroom to support and extend student learning across the curriculum (Lai, 1993). When integrated into the wider curriculum, the use of information technologies may enhance the learning process. In particular the use of information technologies may reduce the risk of failure at school, provide students with immediate access to richer source materials, present information in new and relevant ways, motivate students to try out new ideas and to take risks, encourage analytical and divergent thinking, encourage teachers to take a fresh look at how they teach and the ways in which students learn, help students learn when used in well-designed, meaningful tasks and activities, and offer potential for effective group work (Hinton, 1996: 5).

Computers may help accomplish these outcomes as they are used to perform a variety of tasks. Taylor (1980) provided a framework from which the use of computers may be studied. He suggested that computers can be used as either tutor, tutee, or tool. For the computer to function as a tutor it must first be programmed by experts in the field of study. The student is then tutored as the computer executes the program. This form of computer use has been given many names, the most common being Computer Assisted Instruction (CAI). For the computer to be used as a tutee, it must be tutored by the student. The student must first learn to communicate with the computer in a language that it understands. The Logo computer language is an example of one such language. Finally, the tool use of computers requires the computer to have some useful function programmed into it. The three most common examples of the tool use of computers are word processors, spreadsheets, and databases.

The tutor, tutee, and tool uses of computers have not been used equally in schools (Moss, 1992). When computers were first introduced into schools, it was expected that the emphasis would be on the tutee and tutor uses. Computer programming skills were considered to be an important activity because they were thought to develop general problem solving skills and computer-assisted learning packages were designed to develop specific skills in a particular subject (Moss, 1992). Many teachers, however, did not have sufficient computer skills to support the use of computers in their curriculum area. Also, as some schools chose to place computers in a special location rather than in existing classrooms, it was difficult to incorporate their use in the day-to-day teaching curriculum. There is a clear trend that the availability of computers in the classroom is associated with their use in the curriculum (Pelgrum & Plomp, 1993). These factors, together with a desire to see more students using computers, led to computers becoming objects of study in their own right. Computer awareness and computer literacy courses were offered by most schools.

Some teachers did seek to use computers as tools to enhance student learning in various subjects throughout the curriculum. Fitzgerald et al. (1985) reported that the classroom trend in both primary and secondary education was a movement away from the tutee and tutor uses of computers and a movement toward the tool use of the computers. This movement reflected the idea that computers could be used to develop and enhance the thinking skills of students (Krendl & Lieberman, 1988: 371).

The Tool Use of Computers

Interest in the tool use of computers, particularly use in business, has seen the development of a wide range of sophisticated content-free applications (tools) in recent years. Pelgrum and Plomp (1993) reported that general purpose software programs (tools) were in the top 10 of available types of software in all populations and that one of the major developments in computer activity at all levels of education was the concerted effort to use computers as productivity tools for expressing ideas and recording and analysing information. In those classrooms where computers were used as tools, teachers reported a move towards the integration of computers into the curriculum (Pelgrum & Plomp, 1993).

The tool use of computers has increased and the increase is set to continue. Many more teachers acknowledge the potential usefulness of content-free software than are currently using it (Moss, 1992), perhaps because many teachers are held back due to a lack of training in the use of tool software. Moss (1992) found that while over half of the teachers surveyed are able to use word-processing software, less than half were able to use a database, and only about a quarter can use a spreadsheet or desktop publishing software. Apart from word-processors, most teachers receive no training in content-free software, and teacher skills are especially important in determining the extent to which computers are used in the curriculum (Tinkler et al., 1996). Those teachers with few skills in the use of tool software are unlikely to use this software in the classroom. Teacher training in computer use needs to be a priority if this problem is to be overcome.

Why do many educators acknowledge the potential use of 'tool' software? Why has the emphasis shifted to the use of tools in the classroom? Firstly, using a computer as a 'tool' reflects the 'real world' use of computers (Casey, 1996). Secondly, the use of computers as 'tools' supports the problem-based approach to education rather than the content-oriented approach (Maor, 1993). In this way 'tools' fit in better with the constructivist approach to teaching and learning and, as such, may be more easily integrated into existing curricula. Also, the use of the computer as a tool encourages the development of higher order cognitive skills (Papert, 1980). This may be due to its ability to reduce the cognitive load of students. When students use the computer as a tool, the computer can perform much of the lower order processing required in a task and reduce the student's cognitive load. This leaves the student with more freedom for data manipulation and enables them to conduct more extensive analyses. They also have more freedom to concentrate on higher order strategy selection and control, thus shifting the balance during problem solving from lower order functions to higher-order functions (Moss, 1992; Phye, 1997). This is important as the present information society calls for the development of 'information literacy', which includes the development of higher-order skills in processing information (Tinkler et al., 1996). The use of computers as tools may assist students to develop this literacy.

One tool that has been shown to be very effective in working with information, and may aid the development of information literacy, is database management software. The following sections will consider the use of this tool in the classroom.

Educational Use of Databases

Given the emergence of the global information society, being able to work effectively with information is crucial. In particular, being able to use computers to search, retrieve, and decode relevant information, critically evaluate information, and to analyse, write, present and communicate information have been identified as important skills (Tinkler et al., 1996: 77). These same skills have been associated with the use of computerised databases (Beamish, Au & Bourke, 1998).

In the classroom, students are often asked to work with information and solve problems that require them to make decisions based on information. A database management program is a tool use of computers that may help students to perform these tasks. As a computing tool, it is a record-keeping system whose overall purpose is to maintain information, and to make it available on demand. By using a database students can organise information, manipulate information, and display information (Date, 1990). Databases are of great value in that they provide a capacity to work with information, a structure for data storage, speed in retrieving information, and flexibility in working with and managing information (Bezanilla, 1992). These skills are important because they facilitate problem solving as students work with information (Underwood & Underwood, 1990). This forms an important part of school curricula. In the midst of the current information explosion, it is important that students learn how to access and work with information, as well as to acquire knowledge themselves (Hancock, 1989).

Many researchers report that databases can be used to help students access information and solve problems (Wills, Bunnett & Downes, 1985; White, 1987; Spavold, 1989; Watson & Strudler, 1989; Welford, 1989; Bezanilla, 1992; Ehman, Glenn, Johnson & White, 1992; Lai, 1992; Moss, 1992; Ennis, 1993; Neuman, 1993; Maor & Fraser, 1994; Audet & Abegg, 1996; Leader & Klein, 1996). Databases have been found to encourage children to create mental categories and concepts, hypothesise and generalise, interact with others, and ask questions (Ross, 1984), encourage inquiry learning (Wills et al., 1985; Maor, 1993), encourage the development of flexible thinking skills (Labbert, 1985), develop decision making skills (McClelland, 1986), and enhance problem solving skills (Clyde and Kirk, 1987), and they are used in the real world (Bezanilla, 1992).

The use of databases may enhance project work in many curriculum areas. Students may develop higher order skills such as analysis, problem solving and evaluation (Moss, 1992) and they are encouraged to work with the data more extensively than they might have been prepared to undertake without the assistance of such software.

Use of Databases in the Classroom

Examples of database use in the classroom have been widely published but empirical evidence about their effectiveness is still limited. The literature on the educational use of databases can be grouped into three main categories. The first of these categories contains papers that advocate the use of databases and explains the potential benefits of using such a tool in the classroom. The second category contains papers written by teachers who are reporting on database use in their classrooms. The third and final category of papers reports on empirical research of the effects of database use in the classroom. Before proceeding to consider these categories the following section provides an overview of the types of databases most commonly used in schools.

Overview of Database Use

The most common ways in which databases are used in schools include the use of simple database software on microcomputers, library catalogues and CD-ROMs, and the access of remote databases via telecommunication facilities. In the first approach, students work with completed databases such as the 'The First Fleet' database (Elizabeth Computing Centre, 1982). They may also make use of open ended database management programs (content free software) such as Microsoft Works or Clarisworks in which teachers and students can construct their own data files. The second approach involves the use of a database to access books and reference materials in libraries, while the last approach involves the use of telecommunication facilities.

This approach has not always been widely available to all schools, however, this situation is changing rapidly with the introduction of modems and the expanding use of Internet technologies in schools.

Potential Benefits of Database Use

A large percentage of the early literature on databases contains papers that advocate database use (the first category). These papers explain the potential benefits of using such a tool in the classroom. For example, it has been suggested that databases enhance students' information processing skills (Hoelscher, 1986; Sinclair, 1987; Powell, 1988; Oley, 1989), encourage children to create mental categories and concepts, hypothesise and generalise, interact with others, and ask questions (Ross, 1984), encourage inquiry learning (Wills et al., 1985), encourage the development of flexible thinking skills (Labbert, 1985), develop decision making skills (McClelland, 1986), enhance problem solving skills (Hunter, 1985; Clyde & Kirk, 1987), aid students in the development of higher level thinking skills (Hannah, 1987). All the above papers extol the benefits of the use of a database in the classroom and fall into Collis's (1995) category of "describe and understand". They create the overall impression that the use of databases is not only desirable, but may be necessary for students of the future.

More recently, authors such as Barnett (1993) have proposed that working with databases allows learners to develop both cognitive and metacognitive skills. Information within a database is broken down into separate segments which facilitates self-access entry to the data at multiple points. Learners can then make decisions about how they wish to work with the data, and such decision-making involves the learner in the metacognitive strategies of planning, monitoring and evaluation (Barnett, 1993).

Another potential benefit from using databases is that the information they contain can be more current than information in text books. Crane (1993) reports that this is particularly true of on-line databases where information can be added daily. She proposes that as students use these databases they immerse themselves in current world events. Within this environment students can retrieve information, build critical thinking skills, plan search strategies, judge the relevance and validity of information, and draw conclusions (Crane, 1993).

Database Implementation in the Classroom

The second category of papers are mostly written by teachers who have used databases in their classrooms. These papers mainly fall into Collis's (1995) 'design and pilot testing' category and provide 'snapshots' of teaching and learning practice. Most of the papers report on the success and failure of the various uses of databases throughout the curriculum.

Databases can be used in a variety of ways throughout the curriculum. They can be a source of information, a tool for organising, storing, and retrieving that information, and a tool for presenting information to an audience (Downes, 1989). Some of the ways teachers have reported that they are used within specific subject areas will now be discussed.

Social Studies

One of the first databases produced for school use in Australia was the First Fleet Database: Convicts and Computers (Elizabeth Computer Centre, 1982). This database contained records of 777 convicts who arrived on the first fleet in 1788. Toms (1985) reported use of this database by students in Years 2, 4, and 7. Children had little trouble using the database and it helped them gain a personal and realistic insight into convict days in Australia. Other teachers and researchers also reported positive outcomes when this database was used in their classrooms (Wills et al., 1985).

The First Fleet database prepared the way for teachers to use a number of similar databases in their classrooms. Social Studies became a popular subject area to use databases as they can support all three of the major goals of social studies: skills, content, and democratic values (Hunter, 1987). When data were collected from grave stones in the local cemetery, students were able to search for information, make deductions, and draw conclusions (Coomans, 1985). Dean and Dewsbury (1988) encouraged students to work with a database that contained information about C.Y. O'Connor (an engineer living in Western Australia at the start of the 20th century). They reported that students were totally engaged on task 100 per cent of the time and that during the database activities students interpreted information, assessed evidence, and used logical deduction enabling them to assimilate a large body of knowledge.

Smart (1988) reported that students worked with the QUEST database on different topics in Social Studies. They actively collected, collated, and interpreted data. The database activities encouraged students to work in groups and gave them more autonomy in the learning process. They actively engaged in hypothesis formation and testing and the use of the database encouraged learning situations that otherwise might not have occurred (Smart, 1988).

Riggs (1990) reports that the use of databases can stimulate curriculum integration. Students used databases to organise and select information and in doing so they worked with the basic mathematical concepts of universe, set, subset, union, intersection, and empty set. Students worked in groups to solve problems that involved them in real world experiences (Riggs, 1990). Other educators also commented on this aspect of database use. Unia (1991) reported that students worked on a census project in which they collected data from their neighbourhood. The students used the computer to organise, manipulate, and interpret the data they had generated. These students had not used databases before and learned how to use them without much trouble in a meaningful context (Unia, 1991).

Little (1991) reported how he used a database with students to satisfy the requirements of the Michigan Social Studies Syllabus. He constructed a database on the "Wild West" in which he aimed to have students compare their pre-exercise knowledge about famous people of the "Wild West" with data compiled by the class. As a result students would group data into appropriate categories, identify cause and effect relationships, distinguish between fact and opinion, formulate predictions based on factual information, draw inferences from a variety of sources, compare and contrast information, arrange information in usable forms, draw conclusions, formulate hypotheses, decide if the information is significant to the topic, evaluate the quality of the information, and test hypotheses and revise as needed (Little, 1991: 59).

Markowitz and Crane (1993) explored the effectiveness of online database searching as a tool to foster critical thinking skills in the social studies curriculum. The use of databases seemed to increase students' ability to access information and contributed to the development of students' writing skills by providing immediate feedback. They concluded that the successful implementation of online searching requires the classroom teacher to integrate the technology into the curriculum.

Berson (1996) in a review of the use of technology in Social Studies discussed the use of databases. He argued that database projects have been the foundation for problem-solving activities involving computers, and as a result, the use of computer databases has been an expanding area of computer-assisted instruction in Social Studies. However, as many of the studies are impressionistic and due to a lack of empirical research he concluded there was not satisfactory evidence on which to base the use of technology in Social Studies.[1] Despite this conclusion, it would seem that many teachers report positive outcomes arising from the use of databases in Social Studies.

History

Several teachers have reported using databases within the History curriculum. These reports include using databases to study the first settlers to South Australia using the Sailing South database (Angle Park Computing Centre, 1986). As students worked with this database they were highly motivated and readily accessed information on the topics (Hancock, 1989). Similarly, Adman (1986) reported that students worked successfully with a database of historical data that examined electoral behaviour in the 18th and 19th centuries in England. Loyd-Jones and Lewis (1994) used databases as a teaching and research tool in the History program at Sheffield Hallam University. They concluded that overall their experience using the databases was positive and that databases do have an application in both teaching and research in History.

Jagger, Layton, and Veek (1988) constructed a unit of work designed to teach world history, world geography, and global studies. The unit involved the students in working with several databases and other computer tools to arrange, calculate, and compare data. Students grasped concepts that are difficult for them to obtain using traditional approaches by posing their own questions, testing their own hypothesis, and developing conceptual understanding and critical thinking skills (Jagger et al., 1988).

Little (1995) described a unit of work that examines the life of Amelia Earhart and researches the events that surrounded her disappearance. Students hypothesise likely events that surround her disappearance and work with a computerised database to find evidence to support their conclusions.

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[1] The empirical evidence associated with the use of databases in the classroom is discussed in the third category of papers starting on page 26.

Many of the outcomes discussed above would have been difficult to achieve without the use of databases in the History classroom.

Geography

Geography is another subject in which teachers have made use of databases. (For example, see the report by Jagger, Layton and Veek (1988) mentioned on the previous page.) An important aspect to the success of this database use is the motivation of the student. Errington (1986) reporting on a geography project in which students constructed a database on agricultural properties by sending forms to farmers, argued that if students create their own databases, they become more involved in the topic, gain a greater understanding of the data, and are more motivated to work with the data. This process is enhanced if students are also encouraged to peer tutor and work in groups (Worster & Morrison, 1986).

The use of databases in Geography is a good way to get students to brainstorm, and exercise their critical thinking and research skills (Ramondetta, 1993). Databases are often used in ways in which they are not the prime focus of the lesson but are an essential support component. For example, Geography teachers report using databases that contain information about countries of the world to help students solve the Carmen Sandiego puzzle and developed research skills (Fortman, 1989). In a similar way, an on-line database was used as an information resource when year 12 geography students were completing an assignment on Saturday trading. Students accessed Presscom, a database that contained all the local newspaper's articles since January 1986, and were impressed at the speed that they could access information (Hancock, 1989).

It would seem that teachers in the field of Geography like using databases because they easily fit into their existing curriculum. Students seemed more motivated to work and learn as they worked with the raw information contained within the database. Some students, however, do need help in developing information processing skills (Elder & White, 1989).

Science

The use of databases can be of great benefit in the science classroom as many science activities require the categorisation of data. For example, a year 6 class created their own database on endangered species. Working with the computer gave them greater insights into computers, research, and the topic area (Hancock, 1989). Computer databases also offer a large time saving and means of working with large collections in the Biology laboratory making routine tasks much easier (Silvius, 1993).

Goldberg (1992) used databases in Science to investigate properties of sea shells. The use of the database added an immediacy and dynamic to the study that had previously been missing. Students were in control of questions they wanted to ask and the use of the database encouraged further reading and investigation. By working with the database students also gained experience investigating relationships between two variables. This is an important skill that can be used throughout the curriculum.

Benjamin (1993) reports that on-line databases provide a vehicle for engaging students in the study of real science, studying real problems. By accessing real-time meteorological data stored in an on-line database students were immersed in the scientific process (Benjamin, 1993). Others have used databases to encourage students to engage in scientific research (Norton & Harvey, 1995; Paul & Kaiser, 1996). They report that databases provide an ideal environment to engage students in a research cycle of gathering, searching, sorting, creating, and reporting. Using a database students were able to turn information into knowledge (Norton & Harvey, 1995; Paul & Kaiser, 1996).

Mathematics

In the area of statistics, databases help students to become involved in all phases of the statistical process. Students show a keen interest and often want to collect more information than is needed (Browning & Channell, 1992). By learning to collect, analyse, organise, and interpret their own data, students learn that data can represent information from the real world (Porter, 1993). In a similar way, Healy and Hoyles (1997) used databases to introduce students to research, data handling and analysis. The girls involved in their class worked on establishing a database on storybooks, a topic they were all very interested in. Working with the database gave the students computer experience as well as raising issues about the nature of sampling and the validity of measures.

Various Other Subject Areas

As well as those reported above, databases have been implemented in specific areas of a number of other subjects across the curriculum. In Ecology, students created a computerised field guide (database) of all the nature around their school (Dean, 1992). Also, with the objective of providing urban children with a better awareness of the variety of recreational areas in their state, students constructed a database of outdoor skills (Gray, 1989).

In Medicine, students use a database as a resource tool as part of a Cytology and Histology course. As well as helping students to master their field of study, working with the computerised database also provided an effective method for developing information management skills (Habowsky, Sands, Hogue & Stager, 1990).

Within the Art curriculum, databases have been used to compare and contrast works of art. Students' ability to generalise information from one context to another was tested along with their ability to browse, analyse and judge the importance and development of works of art (Marschalek, 1991). Within Design and Technology, Walter, Hadley, Jacobs, Ritz and Skena (1991) describe how a database can be used to help students with the selection of materials.

Within the English curriculum students used Findabook (Angle Park Computing Centre, 1987), a database that contains information on over 100 children's books, to search for a particular kind of book, and then create their own fields to enter books that they are particularly interested in (Hancock, 1989). Wakefield (1995) describes the establishment of a similar database and claims that the classroom environment was richer for its use.

Helisek and Pratt (1994) describe a classroom activity in which students collect data on the amount of rubbish that each student in the class discards in a day. These data are entered into a database and then analysed. The teachers found the students worked enthusiastically and the extra effort put into the preparation of the lessons was well worth it.

Summary of the Benefits and Implementation of Databases

The papers discussed above in the first two categories of the literature on databases give valuable insights into the implementation on database activities in the classroom. They give encouraging reports of the benefits to both teachers and students.

A theme common to many of the reports on the implementation of databases in the classroom is the development of information processing skills. These skills provide new avenues for instruction and learning. Salant (1990), reporting on the use of the Context Information System in schools in Israel, argues that the use of databases encourages inquiry, information handling, and group interaction skills. By using databases, learners are placed in a role that facilitates the active construction of knowledge as they test hypotheses and engage in the comparative analysis of data. When using databases, students tend to look for relationships among data that would be too laborious and time-consuming to search for using any other approach (Moss, 1992). Once students have become experienced at information processing they can transfer these skills to many aspects of the curriculum (Hoelscher, 1986). In a similar way, Ivers (1997) reported how she used databases as part of 'desktop adventures' for her students. The adventures were designed to help teach students to use a variety of information-processing strategies and to encourage co-operative problem solving. The use of database software was found to encourage co-operative learning and communication amongst students as well as encouraging them to work with information and develop skills in information processing.

In summary, many of the papers discussed above in the first two categories of the literature claim that the use of computerised databases can help students:

1) work with information
2) learn specific domain knowledge
3) develop their higher order cognitive processes
4) develop positive attitudes to computers and their subject areas

The third category of papers focuses on research that seeks to test these claims and a discussion of these papers follows.

Database Research: Testing The Claims

The third and final category of papers report on research of database use in the classroom. These papers fall into the 'hypothesis testing' category (Collis, 1995) and seek to provide empirical evidence to clarify and support some of the claims of the previous two categories. Consider now these claims.

1) Databases Help Students To Work With Information

Many research studies indicate that databases can be used to help students work with information (White, 1987; Rawitsch, 1988; Underwood, 1988; Watson, 1988; Beek & Hurts, 1989; Downes, 1989; Spavold, 1989; Underwood & Underwood, 1990; Mittlefehldt, 1991; Bezanilla, 1992; Ehman et al., 1992; Lai, 1992; Neuman, 1993; Riding & Chambers, 1993; Maor & Fraser, 1994; Norton & Harvey, 1995; Audet & Abegg, 1996; Leader & Klein, 1996; Oliver & Oliver, 1996; Paul & Kaiser, 1996). Students may learn to use a simple database easily and, even at a young age, may perform a number of simple database operations successfully (Bezanilla, 1992). They may select between various approaches to working with information that includes scanning, browsing, searching, exploring, and wandering (Canter, Rivers & Storrs, 1985), and are able to formulate queries to find relevant information (Downes, 1988; Spavold, 1989). When using databases, students are able to solve a greater number of problems (Rawitsch, 1988), and make generalisations about data (Downes, 1988) by engaging in cognitive processes that help them work with information, and improve their inquiry skills (Lai, 1992; Maor, 1993).

Although most studies support the idea that databases help students work with information, the results on efficiency are not as clear. Results from studies in which students worked with information with, and without, the use of computers are inconsistent. Some studies reported that students worked with information much more efficiently when they used a database program rather than traditional paper methods (White, 1987; Beek et al., 1989; Riding & Chambers, 1993). Other studies reported mixed or inconclusive results (Rawitsch, 1988; Ehman et al., 1992). For example, Rawitsch (1988) in a study of 275 eighth graders concluded that students solved a greater percentage of problems correctly when they used a computer than when they didn't, however, they took longer to complete their work and therefore there was no increase in learning efficiency.

Results on the efficiency of learning using databases may be inconclusive due to the number of factors that may affect students' ability to work with them. These include:

- lack of keyboard skills,
- lack of understanding of the structure of the database,
- difficulty in performing database operations,
- lack of training in the use of databases,
- poor design of the database interface.

The results of database studies may be inconsistent because not all studies measured or allowed for these factors. They are important and warrant more detailed consideration.

Lack of keyboard skills

Lack of keyboard skills has been shown to affect the efficiency with which students work with computerised databases (Spavold, 1989). Students can become frustrated at the pace at which they are able to work if they do not have adequate keyboard skills, particularly during data entry (Bezanilla, 1992).

Lack of understanding of the structure of the database

Students need help in understanding the structure of the information in the database (Downes, 1989). A lack of understanding often leaves students feeling confused and overwhelmed. One factor that has been identified as impacting on students' understanding is the prior knowledge that they bring to the classroom. Students are hindered from accessing information in a database if there are mismatches between their knowledge bases and conceptual structures, and those inherent in the database (Bezanilla, 1992; Neuman, 1993). These conceptual barriers substantially increase cognitive load and restrict student access to the information contained in the database. As a result, students make incomplete use of the power of the computer (Downes, 1989; Bezanilla, 1992), or may completely misuse the data (Ehman et al., 1992).

Teachers need to spend more time at the commencement of database activities making sure that students have adequate understanding of the structure of the database. In particular, students need to have an understanding of the categories in which the information is stored within each database (Downes, 1989). Spavold (1989) reported that children who compiled a database were able to formulate queries better and operate more efficiently than similar groups using the same system for interrogation only. Those children who had a more complete understanding of the structure of the data within the database were better able to work with the available information.

Difficulty in performing database operations

The ability to query a database successfully is a major factor that differentiates between novice and expert users (Audet & Abegg, 1996). Although many students can perform simple database operations within a relatively short period of time, the full range of database operations are not as easily acquired (Bezanilla, 1992). In an analysis of children's performance on database tasks, Bezanilla (1992) found support for a hierarchy of tasks. Easy tasks included the retrieval of a characteristic of an object, the retrieval of objects with a given characteristic, and sorting data with given characteristics. Harder tasks are those that required dealing with more than one variable at a time and included the retrieval of objects with more than one given characteristic, and the finding of a relationship between two variables.

Many students have difficulty generating queries for a database particularly when these queries fall into the harder categories mentioned above. Students have particular difficulty with the logical connectors AND/OR (Underwood, 1988; Spavold, 1989; Bezanilla & Ogborn, 1992). There is also evidence of a gender effect with boys formulating queries better than girls (Spavold, 1989).

Lack of training in the use of databases

If students are to use databases successfully, extra time needs to be allocated to content-based units of work to allow for the development of information skills along with knowledge and concepts (Downes, 1989). Many teachers assume too much about student database understanding and skills. They do not give their students adequate practice in the development, and use of information processing skills before they expect them to be able to use a database successfully (Downes, 1988; Ehman et al., 1992). This is evident in the way that many students use only the surface features of a database and continue to perform tasks manually that the computer is able to do more efficiently (Maor & Fraser, 1994). For example, many students continue to use browse strategies rather than using sorting and selecting strategies that would be much more efficient (Bezanilla, 1992).

Poor design of the database interface

Students perform poorly when working with information in a database that has a poorly designed interface. Students' performance can be hindered by crowded and confused screens, complex and conflicting symbol systems, lack of graphic and other mechanisms for highlighting relevant information (Neuman, 1993).

In summary, databases can assist students when working with information although the effects on efficiency are not clear. Various factors have been shown to affect the efficiency with which students work with information contained in computerised databases. Educators need to be aware of these factors as they implement the use of database technologies in the classroom.

2) Databases can help students learn specific domain content.

Learning involves the integration of externally accessible information with an individual's existing and emerging personal knowledge (Wildemuth, Blick, Friedman & File, 1995). As students work with databases, their domain knowledge changes (Michel, 1994). Through knowledge and experience with databases, disparate pieces of information may become integrated into complex cognitive schemata (Audet & Abegg, 1996). This enables students to move towards expertise in the domain in which they are working (Derry, 1996). This in turn helps in further knowledge construction and acquisition (Boekaerts, 1997).

An increasing number of teachers are using databases in classroom instruction to assist in knowledge construction (Rawitsch, 1988; Langhorne, 1989; Northrup & Rooze, 1990; Sheingold & Hadley, 1990). This increase has been supported by research that points to the positive influence working with databases has on knowledge construction (Ehman et al., 1992; Lai, 1992; Ennis, 1993; Riding & Chambers, 1993; Maor, 1993; Leader & Klein, 1996; Audet & Abegg, 1996).

Learning is a constructive process in which conceptual change occurs through interactions between students and their environment. When using computerised databases, learners can have significant control over the direct environment because they can select, process and integrate the information with which they are working (Audet & Abegg, 1996). Consequently, as they work with knowledge in more active and constructive ways, students show a deeper understanding of knowledge and concepts acquired through database activities (Lai, 1992).

Experts in a domain have their knowledge organised in complex structures (Derry, 1996). Databases provide considerable support for students' construction of knowledge in that the database categories may help to provide students with a knowledge structure (Underwood, 1988). Certainly, those students who have a better understanding of the database categories are able to work more effectively (Spavold, 1989). Assistance with knowledge structure may be one way in which students are able to accommodate knowledge increases and changes.

Databases may facilitate knowledge construction as students find information easier to access and easier to work with[2]. Riding and Chambers (1993) reported on a study in which 40 students at undergraduate level received a series of questions of various types (factual, interpretative, comparative, and deductive) on development in the third world. Given either a conventional textbook or the same information in a database on CD-ROM, they found a significant difference with the electronic mode group being superior on all question types.

Although research does support the idea that students can learn specific domain knowledge when using databases (Lai, 1992; Audet & Abegg, 1996), the factors influencing knowledge construction need further clarification. Downes (1988), while supportive of the use of databases to help students acquire domain specific knowledge, pointed out that students who worked with the First Fleet database developed generalisations but could not describe the evidence upon which they had based these generalisations nor could they describe how they would test them. Other research has indicated that some students are better at acquiring knowledge than others. For example, students who preferred structured work styles performed better than those whose work style tended toward exploratory (Rawitsch, 1988).

Various factors have been identified that affect how students construct knowledge using databases. Lack of prior knowledge of both databases and the content of databases impedes knowledge construction (Ehman et al., 1992) as students lacking this knowledge may have trouble formulating effective questions and trouble querying the database to answer their questions. Not all questions promote knowledge construction and act as a stimulus to higher cognitive skills (Underwood, 1988) and when students are confronted with a data set they often need help in formulating appropriate questions and performing database queries. Also, databases are often used to expose students to real world data and relationships in this data are not always straightforward. As a result, students can find the interpretative stages of database activities difficult (Healy & Hoyles, 1997). Finally, logistical factors may play a part in

[2] For a list of studies on databases and information processing, see the previous section entitled Databases help students to work with information.

affecting how students construct knowledge using databases. Particularly as knowledge construction activities in real world contexts are often open-ended, there may be a conflict between these activities and the demand for curriculum coverage (Audet & Abegg, 1996). All of these factors may affect knowledge construction using databases in the classroom.

Also, Maor (1993) warns that databases by themselves might not help students acquire knowledge and develop higher-level inquiry skills. It seems to be the total learning environment, that is, the role performed by the students, the teacher, and the computer, which enhances the construction of knowledge. This will be considered in more detail in Chapters 4 and 6.

3) Databases can help students develop higher order cognitive processes.

The higher-order processes of analysis, synthesis, and evaluation, make up the highest three levels of Bloom's (1956) taxonomy of educational objectives. Many researchers claim that when students work with computerised databases they develop these, and other, higher order skills (White, 1987; Rawitsch, 1988; Degl' Innocenti & Ferraris, 1988; Watson & Strudler, 1989; Langhorne, 1989; Ryba & Anderson, 1990; Bezanilla, 1992; Ehman et al., 1992; Ennis, 1993; Neuman, 1993; Williams, 1994; Maor & Taylor, 1995; Audet & Abegg, 1996; Healy & Hoyles, 1997). For example, students may engage in tasks that require analysis, problem solving and decision making (Welford, 1987; Ryba & Anderson, 1990). Students are involved in creating, analysing, synthesising, and evaluating (Welford, 1987; Watson & Strudler, 1989).

Recent studies have also supported claims for the development of higher-order skills as students work with databases. Ehman et al. (1992) reviewed six major field studies that reported cognitive outcomes when students worked with databases and found support for the development of higher-order thinking skills. Students interrogating simple databases may develop skills in classifying, comparing, hypothesising, generalising, and using Boolean logic (Bezanilla, 1992). They engage in a number of cognitive processes in which they discriminate information, categorise information, formulate, and evaluate hypotheses (Lai, 1992). Students working with a computerised database showed significant improvement in application, analysis, and interpretation (Maor & Fraser, 1994). The higher-order thinking skills developed while using databases help students to classify, differentiate, combine separate ideas, contrast and compare information and solve problems (Ennis, 1993). Using databases also gives students the opportunity to develop hypotheses, make inferences, test hypotheses, analyse and modify tests of various hypotheses, identify and evaluate data, and draw conclusions (Maor & Taylor, 1995).

All of the above studies support the idea that as students work with databases, they develop higher order skills as data are analysed, questions formulated, searches planned, and results reviewed.

Databases and Metacognition

As well as the higher-level skills of Bloom's taxonomy, the use of computers may assist students to develop other high-level skills. Research concerning effective learning, in both adults and children, highlights the importance of metacognitive skills (Baird, 1992). Metacognition involves the regulation of one's cognition. It involves awareness of the cognitive strategies that are available to the learner and the ability to be able to regulate cognition during problem solving. This usually involves the ability to be able to plan, monitor, and evaluate during problem solving[3].

The use of metacognitive skills may enhance the learner's chance of success during problem solving (Flavel, 1979; Jong & Ferguson-Hessler, 1996). As computer activities may help learners engage, practice, and acquire metacognitive skills, they may also assist students with problem solving (Williams, 1994). The computer can 'short-circuit' learner cognition by taking on a large amount of the information processing burden of the learner (Kozma, 1987; Lambrecht, 1993). The activation of higher order mental operations is then made possible as the computer relieves learners of low-level, tedious operations and heavy reliance on memory capacity (Salomon, Perkins & Globerson, 1991). In particular, when students work with a computer database they are relieved of the burden of the low-level tasks of searching, sorting, and manipulating information and they are left free to concentrate on the higher order tasks of planning, classifying, comparing, hypothesising, generalising, and evaluating (Ryba & Anderson, 1990; Maor & Taylor, 1995). Students also have the opportunity to be more metacognitive as they monitor and reflect upon their cognition. In many learning situations, students rarely have the opportunity to do this as lack of immediate

[3] For a fuller discussion of metacognition see Chapter 6.

feedback makes it difficult. In a computer-aided environment, immediate feedback is provided by the computer which motivates learners to evaluate their decisions, and reflect upon their progress and goals (Butler & Winne, 1995).

The use of computers may further enhance the development of metacognitive skills as computers may function within a learner's zone of proximal development (Vygotsky, 1978; Salomon, Globerson & Guterman, 1989). The computer may act in a similar role to the expert figure in social cognition theory. Learners, working with more capable peers, may internalise the very processes in which they are working if they are provided with an explicit model (Forman & Cazden, 1985; Salomon et al., 1989). Working with a more capable peer may enable the learner to activate mental operations that the learner would have difficulty using without the partnership (Palinscar, Brown, & Martin, 1987; Salomon et al., 1989). Also, more capable peers can provide learners with the appropriate metacognitive guidance (Salomon et al., 1989). The use of computerised databases accomplishes two of these three functions. Databases provide models for information representation, and they assist in the activation of higher order cognitive processes by relieving learners of low-level operations that are a drain on memory capacity. They do not, however, provide any metacognitive or human-like guidance (Salomon et al., 1989). Researchers have designed software that provided metacognitive guidance, but in the absence of a peer or teacher, learners did not always expend the effort to make use of such (Salomon et al., 1989). It would seem that peers and/or teachers need to fulfil this role.

The development of higher-order skills is not a simple process. Students need many opportunities to develop and practice higher-order thinking skills if they are to become good problem solvers (Dudley-Marling & Owston; 1988). For example, students often find it difficult to identify and hypothesise relationships among different categories of information in a database file (Lai, 1988). Systematic training and practice is required to facilitate the learning of these and other information processing skills (Lai, 1992). An emerging trend in the literature concerns the important role played by the teacher in developing these skills (White & Gunstone, 1992).

Computerised databases by themselves do not help students develop higher-level inquiry skills. It is the total learning environment including the students, teacher, and computers, that encourages the construction of knowledge and development of higher order thinking. A key element is the teacher's epistemology (Maor & Taylor, 1995).

Also, teachers enhance the development of higher-order skills when the use of databases in the classroom is supported by an appropriate methodology (Guttormsen, 1986; Taylor, 1987; Van Deusen & Donhan, 1987; Watson & Strudler, 1989; Elder & White, 1989; Welford, 1989; Maor & Taylor, 1995). While computerised databases provide a good medium through which learning may occur, teachers need to implement sound teaching strategies to engage students in higher order thinking (Elder & White, 1989; Watson & Strudler, 1989; Welford, 1989). Teachers need to interact with students as they use the computer (Van Deusen & Donhan; 1987) and intervene when necessary to encourage higher-level thinking (Guttormsen, 1986). Teachers should function as facilitators or 'coaches' in this learning environment. They should counsel, urge, warn, judge, and suggest alternatives and models (Taylor, 1987). They can provide metacognitive guidance and encourage students during information processing activities.

The structure of the curriculum, and the time given to database activities, also have a large impact on the successful use of computers in the classroom. The mere presence of computers in the classroom does not guarantee learning. When applied to open-ended, problem-based instruction, computers can conflict with the demand for curriculum coverage (Newman, Morrison, & Torzs, 1992). Rawitsch (1988) found a difference in the number of problems solved that favoured computer classes, but he also found that more time for problem solving was required by these students. Time needs to be given for students to develop and practise their skills. Students also need instruction in the scientific method and hypothesis testing if they are to produce useful results. Burbules and Linn (1991) argued that traditional classrooms provide an inaccurate representation of knowledge and of how scientific thinking is generated. In these classrooms, students have opportunities to examine only superficial ideas but do not have sufficient opportunity to construct meaningful representations of those ideas. For students to construct knowledge and develop higher order skills they need the time to do so.

In summary, it would seem that the use of computerised databases does encourage students to engage in higher order thinking. For this to occur learners need to be supported by good teaching practice and given sufficient time to develop and practice these skills.

4) Databases help students to develop positive attitudes

Most studies have reported positive student attitudes to the use of computerised databases and found they encouraged high levels of student motivation across a range of ages (Guttormsen, 1986; Pea & Sheingold, 1987; Downes, 1988; Rawitsch, 1988; Spavold, 1989; Elder & White, 1989; Bezanilla, 1992; Lai, 1992; Benjamin, 1993; Ennis, 1993; Helisek & Pratt, 1994; Maor & Taylor, 1995; Leader & Klein, 1996).

More specifically, studies found that most students enjoyed using the computer (Downes, 1988). Children liked using the computer and preferred to work in groups thus gaining the support from their peer group (Spavold, 1989). Students enjoyed databases because in their estimation there was less reading involved, it was more fun, information was easier to find and the format made comparisons easier (Guttormsen, 1986). Students preferred working on the computer to traditional methods of problem solving (Rawitsch, 1988). Students responded favourably to the materials and teachers reported that "computers really seem to captivate the students" (Elder & White, 1989). Student learning appeared to be fun, interesting, challenging, and involving, with the use of computer databases (Ehman et al., 1992).

Not all teachers involved in research studies expected high student motivation to result. Underwood (1988) in a study of the use of computer-based information handling packages in 18 classrooms, compared the expressed objectives of teachers using databases against recorded outcomes. Only six per cent of the teachers indicated that they expected high motivation to be an outcome, however, 61 per cent of the teachers reported it as an actual outcome.

More recent studies also support the idea that students have high motivation when they are working with databases in the classroom. When using computerised databases, students enjoyed science (Benjamin, 1993). Students indicated a general liking for both the use of a database program and involvement in database tasks (Leader & Klein, 1996). Students enjoyed database projects and indicated that they would like to spend more time working on computers in the future (Lai, 1992; Ennis, 1993). Both Bezanilla (1992) and Maor and Taylor (1995) reported that students had positive experiences with computers and were motivated to work throughout the database activities.

The results from many of the studies could best be summarised by Helisek and Pratt:

> Looking back on this project, we were more than repaid for our time and energy in student enthusiasm and excitement.
>
> (Helisek & Pratt, 1994: 28)

Summary and Conclusion

It has been claimed that when a computer is used as a tool it becomes both an amplifier of human capabilities and a catalyst to intellectual development (Underwood & Underwood, 1990). From the literature reviewed, it would seem that databases can assist students to work with information, and acquire knowledge and problem solving skills through the development of cognitive, and higher order thinking skills. Using databases in the classroom also encourages students to develop positive attitudes to their work and motivates them to learn. As a consequence powerful learning situations can result (Underwood, 1988).

Attention does have to be given to Welford's (1989) warning that for meaningful learning to occur, the use of databases needs to be supported by an appropriate methodology. Consideration needs to be given to the pedagogy surrounding the use of databases in the classroom as the total learning environment determines the success of database activities (Maor & Taylor, 1995). The use of databases by themselves does not necessarily impact upon student cognition and learning. This will be further explored in the next chapter.

Chapter 3

Towards a Model of Learning Using Computers in the Classroom

Introduction

The present study is concerned with the use of computers, and more specifically database management software, to enhance student learning. Maor and Taylor (1995) call for the consideration of the impact of the total learning environment on student activities. Having considered the benefits associated with the use of computerised databases in the classroom in Chapter 2, attention is now focused on the factors that may affect successful implementation of database activities in the classroom. Maor (1993) argues that databases by themselves might not help students acquire knowledge and develop higher-level inquiry skills. It seems to be the total learning environment, including the role played by the students, the teacher, and the computer, that determines the success of database activities. Within the classroom, an appropriate context must be provided for effective learning to occur (Alexander, 1995; Biggs & Moore, 1993: 450).

Various theories of learning have not always recognised the influence of the total learning environment on learning outcomes. One of the shortcomings of information processing theory was the failure to take into account the learning environment and the reasons why students engaged in learning (Mayer, 1996). Some models of self-regulation in learning suffer from the same problem (Alexander, 1995; Corno, 1995; Pressley, 1995; Schunk, 1995; Zimmerman, 1995). On the other hand, the constructivist approach to teaching and learning focuses on learners constructing their own understandings within a learning context (Maor & Taylor, 1995). This context has a considerable influence on the student learning processes and consequent learning outcomes (Entwistle & Ramsden, 1983; Biggs, 1993; Clarke & Dart, 1994). From the constructivist perspective, students' construction of knowledge is facilitated by teachers who provide an environment in which students can clarify their ideas, expose their ideas to conflict situations, and reconstruct their ideas (Hand, Lovejoy & Balaam, 1991). This learning environment is very important and deserves more detailed consideration.

The Presage-Process-Product Model

Schools do make a difference to student achievement and to latter functioning in adult life (Hattie, 1992). This does not occur as a matter of course but as the result of planned learning interactions in the classroom. What happens in schools and classrooms was well represented by Biggs (1993) and Biggs and Moore (1993) as they adapted Dunkin and Biddle's (1974) model of teaching. This model considers that learning in the classroom takes place within a dynamic system and that a wide range of factors may influence this system.

> The 3P model is not a theory but a descriptive framework, which helps order the components of a particular system in a coherent way. Using such a framework, student learning is clearly seen to take place in a teaching context that affects both the nature of learning, and its outcomes. Using information processing constructs, however, it is easy to overlook the teacher, or any other aspect of the context of learning, simply because they have no place in the framework.
>
> (Biggs, 1993: 15)

The model contains three phases: presage, process, and product (Figure 3.1).

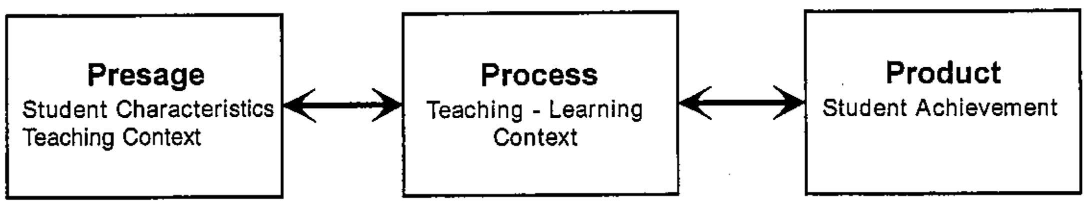

Figure 3.1 The 3P Model (Adapted from Biggs & Moore, 1993: 448)

Presage factors are aspects of student and teaching contexts that exist prior to the immediate action in the classroom. These influence process factors, the teaching-learning processes in the classroom, and these in turn influence the product factors, usually thought of in terms of student achievement. These three factors form a dynamic system in the classroom (Biggs & Moore, 1993: 449) and form a suitable framework for a discussion of student learning within a computerised environment. Studies cited in Chapter 2 show that when computers, and more particularly databases, are used in the classroom there are a number of factors that may influence the success of their implementation. It is important to consider all such factors and we start with consideration of the various presage factors.

Presage Factors

When students work with databases there are many presage factors that exist prior to the classroom activity that may affect student learning. Both students and teachers contribute presage factors to the learning system. Student presage factors are usually relatively stable, learning-related characteristics of the student (Biggs, 1993). In the classroom using computerised databases these factors may include: computer experience (Chen, 1986; Beamish, 1988; Levin & Gordon, 1989; Bezanilla, 1992; Stubbs, 1994; Maor & Taylor, 1995; Corston & Colman, 1996; Joiner, Messer, Littleton & Light, 1996), gender (Levin & Gordon, 1989; Bohlin, 1993; Makrakis, 1993; Okebukola, 1993; Shashaani, 1993; Colley, Gale & Harris, 1994; Bunderson & Christensen, 1995; Makrakis & Sawada, 1996; Joiner et al., 1996; Durndell & Thomson, 1997; Shashaani, 1997), personality (Bozeman, 1978; Beamish, 1988; Katz & Offir, 1991; Francis, Katz & Evans, 1996), preferred approach to learning (Biggs, 1987), flexibility in learning (Cantwell, 1994), and knowledge and information processing ability (Biggs, 1993; White, 1987).

We now consider each of the student presage factors of computer experience, gender, personality, preferred approach to learning, flexibility in learning, and previous knowledge and information ability, before turning our attention to the teaching context.

Computer Experience

Experiences that students have with computers affect their attitudes to computers and their success in using them (Chen, 1986). Previous computer experience is a more accurate predictor than gender of their competence, level of computer usage, and attitudes toward computers (Levin & Gordon, 1989; Corston & Colman, 1996). Stubbs (1994) found that students' previous computer experience was a major influence on their level of anxiety when using computers. Those students who had used computers more reported positive attitudes toward computers and felt better about using them. Computer experience also affects how successful students are at using them. Research has indicated positive relationships between computer experience and problem solving performance (Joiner et al., 1996). Students who have had more computer experience are also more likely to say that they plan to study and work with computers in the future (Doornekamp, 1993). Giving students the opportunity to gain computer experience would seem to be very important in helping them to use computers successfully and establishing positive attitudes to their use.

Computer experience has both direct and indirect influences on achievement. Experience has been shown to influence attributions which in turn influence attitudes and performance (D'Amico, Baron & Sissons, 1995). Students attribute success at school to a number of different things. When students are young they believe that they will do well in school if they work hard (Stipek & Gralinski, 1990). As students get older, they are more likely to attribute success and failure to ability, which they often perceive as being beyond their control (Paris & Byrnes, 1989). Those students who are consistently successful in school develop a high academic self-concept and see themselves as having high ability. These children expect success and are more likely to expend effort to achieve it. A background of successful computer experience will help students view themselves as having ability when working with computers. This in turn will give them motivation to continue to work with computers, even on difficult tasks (D'Amico et al., 1995).

By themselves, quantity and frequency of computer experience may not be enough to ensure positive attitudes and a commitment to computer use. Stubbs (1994) reported that while 25 per cent of lower secondary school students had experienced a wide range of computer applications, between 30 per cent and 40 per cent of the lower secondary school students had experiences limited mostly to playing games. Similarly, Doornekamp (1993) found that while about 40 per cent of the students used a computer very frequently, a large percentage of this use was for word processing and to play games. These computer experiences alone are not a significant predictor of commitment to computer use (Kay, 1990) because they seem to lack a quality of experience that is important. Even in schools where computers are being used regularly in the classroom, teachers are still not necessarily using computers as learning tools. Students spend more time learning how to use software than using it in problem solving and learning situations (Becker, 1991). To ensure positive attitudes to computers, and success in using them, students need to participate in quality experiences in the classroom.

The fact that experience plays an important role in determining attitudes and achievement should not come as a surprise. Constructivist theory emphasises the importance of prior knowledge and experience and the way they effect the acquisition of new information (Reed, Ayersman & Liu, 1996). Particularly in the area of computer based learning, those students with less experience need to spend more time learning how computers work in general, and more time coming to terms with specific tasks (Reed et al., 1996).

Experience with Databases

Databases are generally used within a problem-solving environment in the classroom. Most studies show that the more experience students have gained using databases, the more positive their attitudes to using them will be, and the more they will achieve while using them (Diem, 1985; Enochs, 1985; White, 1987; Bezanilla, 1992; Maor & Taylor, 1995).

One possible explanation for this is that students need to use a variety of skills and strategies to work successfully with a database. They need to be familiar with routine operations, such as turning the computer on, and starting the database with which they wish to work. Students also need to be able to browse through the data and perform searches to select relevant data. It is only when these skills have been practised, internalised, and become automated, that the learner will be able to expend less energy on their operation and spend more time and energy on the execution of higher-order and metacognitive strategies. This in turn will give students more control over the use of databases and those students who wish to learn at a deep level may do so. They gain executive control over the strategies they wish to employ and control over the direction of their database use. The gaining of experience in using databases is a very important step in the development of effective information processing skills using this software.

Factors That Influence Experience

Several factors have been identified as having an influence on the amount and quality of students' computer experiences.

Age

The way students use computers changes with age. In a recent study of computer use in Australian homes, Downes (1997) reported that the percentage of household members actually using computers increased with age till their mid-teens and then decreased to adulthood. The type of use also changed with the age of the user. Males' use of games peaked in their early teens and then decreased to adulthood while their use of computers for educational purposes peaked in their mid to late teens and then declined. Females had a similar pattern to males although females reported a much lower use of games and a much higher use of computers for educational purposes (Downes, 1997).

Gender

The research on computer experience highlights an important interaction with gender. Males have more positive attitudes to the use of computers than females (Martin, 1991), and were more likely to have used computers than females (Colley et al., 1994). For example, Sheffield (1996) noted that males reported more experience with database software than females, and consequently males rated themselves higher in database proficiency and had better attitudes to using databases. When experience is controlled for, males and females often have the same levels of interest (Chen, 1986; Colley et al., 1994).

Experience does not necessarily have the same effect on both genders. For boys, attitudes became more positive with experience, while experience does not always positively influence girls' attitudes toward computers (Martin, 1991)[1].

Home use

Students' acquisition of computer knowledge takes place largely outside the school (Tully, 1996). Those students who own a computer at home report more positive attitudes to computers because they were more familiar with them (Houle, 1996).

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[1] See the section on Gender Differences later in this chapter.

These students felt a greater need for computers in their lives, and were more motivated to become familiar with them (Levin & Gordon, 1989).

Downes (1997) reported on the results of a number of recent studies into the use of computers in Australian homes. The results from her study were summarised in Table 3.1. In 1996, 30 per cent of Australian households owned computers. This represents approximately 2.5 million units (some households had more than one computer). Overall, more children used the computer at home for educational purposes than for game playing in each age group except the youngest. Variables linked to household ownership included geographical location, income, level of education, and the presence of children and parents who used a computer as part of their employment or business (Downes, 1997).

Table 3.1 Percentage of Total Population Uses of Household Computers

		Use				Main Use			
Age	Gender	% Games	% Educ	% Work	% Other	% Games	% Educ	% Work	% Other
5-9	male	30.6	23.0	0.0	1.3	26.1	6.0	0.0	0.4
	female	24.5	23.6	0.0	1.4	16.7	11.6	0.0	0.8
10-14	male	44.2	51.5	0.1	4.4	34.4	13.0	0.0	0.5
	female	39.7	58.2	0.0	3.3	21.1	26.1	0.0	0.2
15-17	male	43.5	56.8	0.8	9.9	23.0	23.9	0.1	1.8
	female	32.7	57.7	1.5	6.5	6.0	40.6	0.1	0.8
18-24	male	21.7	25.3	6.7	11.2	11.3	14.4	2.6	2.8
	female	12.3	25.9	6.6	9.5	3.6	19.1	2.4	1.8
25+	male	9.5	8.5	17.6	16.2	3.8	3.4	11.1	4.0
	female	5.3	6.6	9.9	9.2	2.1	3.5	6.4	3.3

(Downes, 1997: 9)

Greater computer experience at home is associated with low computer anxiety, with higher confidence for males and greater liking for females (Colley et al., 1994). Role models within the house also play an important part in determining student attitudes to computers. Colley (1994) found that the attitudes of both males and females were more positive if they had a brother who used computers, but the influence of the father's use was positive for males only, while the influence of mother's use was positive for females only.

Having a computer in the home may facilitate mastery of computer technologies. Tully (1996) describes knowledge associated with computer use and emphasises two aspects: operation and mastery. Operation involves dealing with software and hardware while mastery involves the strategic use of technology. The latter is best developed through 'suitable practical use' which often takes place outside the classroom.

School use

Access to computers has been found to influence the level of students' computer experience (Doornekamp, 1993; Stubbs, 1994; Preston, 1995). For many students, restricted use of computers outside of the classroom makes what occurs within the classroom even more important. Unfortunately, computer use in schools does not always have positive results for everybody. For females, taking a course in computers may not positively influence their attitudes toward computers, but for males, attitudes become more positive with the experience of a computer course (Martin, 1991). The success of students' experiences at school often depends upon the methodologies used in the classroom (Welford, 1989). A discussion of these methodologies follows in Chapter 4.

Other use

Some students use computers at places other than home and school. A large number of students use a computer at a friend's place with this use being highly gendered (Durndell & Thomson, 1997). Also, some students use computers at their work-place. Computer experience at a job is an important discriminant regarding computer attitudes, anxiety, and self-efficacy. Work experience may be more important than school classes on the impact on computer attitudes (Houle, 1996).

Summary of Computer Experience

Personal experiences when working with computers affect students' reactions to having to work with them (Martin, 1991). Students' previous computer experience may have a greater influence than gender on their competence, level of usage, and attitudes toward computers (Arch & Cummins, 1989; Levin & Gordon, 1989; Corston

& Colman, 1996). It would seem that this presage factor is one of the most important in determining the success of database activities in the classroom.

Gender Differences

Gender has been identified as an important presage factor affecting the use of computers in the classroom (Levin & Gordon, 1989; Bohlin, 1993; Makrakis, 1993; Okebukola, 1993; Shashaani, 1993; Colley et al., 1994; Bunderson & Christensen, 1995; Makrakis & Sawada, 1996; Joiner et al., 1996; Durndell & Thomson, 1997; Shashaani, 1997). There are clear differences in the way boys and girls work with, and relate to, computers. Most studies have found that boys are more confident using computers, spend more time interacting with computers, and consider themselves better at using computers than girls (Okebukola, 1993; Makrakis & Sawada, 1996). Girls often rate their ability to work with computers lower than that of boys even though their performance may be better than that of their male classmates (Shashaani, 1997). As a consequence, girls are at a disadvantage in the computer world. Females are highly underrepresented in computer courses, professional computer jobs, and home computer use (Bohlin, 1993). The gender gap gives problems from a vocational perspective, from a psychological perspective and from a social perspective (Makrakis, 1993).

It can be argued that the gender difference in computer use leads to a gender difference in performance. Boys perform significantly better than girls on many computer tasks and studies have found a positive relationship between computer experience and problem-solving performance (Bernhard, 1992; Joiner et al., 1996). These differences have been found to be reduced and even disappear when girls are given equal opportunity to work on computers (Underwood & Underwood, 1990). Studies reporting gender differences in computing achievement show that such differences disappear when the effects of computing experience are controlled (Chen, 1986; Bear, Richards & Lancaster, 1987; Loyd, Loyd & Gressard, 1987; Clarke & Chambers, 1989). Some studies even show that girls outperform boys when they have equal use of computers (Ayersman, 1996).

Research studies point to gender differences in attitudes to computing although the empirical evidence is inconsistent. Some researchers have found little or no gender differences while others have found significant attitude differences[2]. Studies have found that males and females alike were aware of the value and benefits of the use of computers in daily life (Shashaani, 1993), however, many studies have found boys to have more positive attitudes to computers than girls (Levin & Gordon, 1989; Martin, 1991; Reinen & Plomp, 1993; Shashaani, 1993; Colley et al., 1994; Makrakis & Sawada, 1996). Boys were found to like computers more (Martin, 1991; Colley et al., 1994; Makrakis & Sawada, 1996), while girls had less interest in learning with computers (Shashaani, 1993), and less confidence and more anxiety when working with computers (Shashaani, 1993; Reinen & Plomp, 1993; Colley et al., 1994). These results were evident even though girls had demonstrated equal competencies in computer use (Shashaani, 1993), and led some educators to call for a revision of the way gender issues are addressed (Makrakis & Sawada, 1996). Whitley (1996) points to the relative nature of some of the gender differences found. Although women scored lower than men on attitude scales, the means of both groups can be high. Consequently, it would be incorrect to conclude that women have negative attitudes toward computers. Rather, it might be concluded that women exhibited satisfactory attitudes to computers, but their attitudes are not as favourable as men.

Other studies have found no gender difference in attitudes (Makrakis, 1993; Reinen & Plomp, 1993; Francis, 1994), but there is little evidence to suggest that girls may have more positive computer-related attitudes or lower levels of computer anxiety than boys (Francis, 1994). Some studies did report a gender difference in attitudes but found that the difference disappeared when allowance was made for prior computer experience (Levin & Gordon, 1989; Dyck & Smither, 1994). In fact it has been suggested that investigating gender differences in attitudes toward computers without taking prior computer exposure into account distorts the picture (Levin & Gordon, 1989).

Studies on attitude may report conflicting results owing to the way that attitude is measured. Researchers have used at least 15 different measures of attitude to computers (Kay, 1992). Some of these measures contained a gender bias in some of the items (Wiburg, 1995). More work needs to be done to consolidate the way attitudes to computers are measured.

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[2] For a more detailed discussion of attitudes to computers see Product Factors later in this chapter.

Reasons for Gender Differences

The gender differences reported above have been accounted for in a number of ways that include previous computer experience, stereotyped attitudes, perceived usefulness, attributions, associations with other male oriented subjects, parental attitudes, socialisation patterns, and the lack of female role models. The inconsistency in the empirical results leads one to suggest that the factors that influence gender differences are complex and more than a simple dislike of computers by girls. These factors deserve more detailed consideration as gender differences in attitudes towards computers, and performance using computers, affect the context within which the student is learning, and subsequently the quality of learning.

Computer Experience

Computer experience plays a large role in influencing how students work with computers. The pattern of use of computers at schools and at home is putting girls at a disadvantage relative to boys with boys much more likely to have used computers (Colley et al., 1994). Studies have reported that girls use computers less at home (Levin & Gordon, 1989; Durnell & Thomson, 1997), at school at primary level (Siann, Macleod, Glissov & Durndell, 1990) and at secondary level (Collis, Kass & Kieren, 1989; Taylor, 1990), and at tertiary level (Clarke & Chambers, 1989; Bunderson & Christensen, 1995).

In the home the use of computers is highly gendered (Collis et al., 1989). Boys report a higher level of use of both their own computers and of a friend's computer (Durndell & Thomson, 1997). Boys are more likely to use a computer at home than girls, especially for playing games, and computers are generally bought for males (Joiner et al., 1996).

In the school, the use of computers has increased along with student knowledge about information technologies, with the male advantage over females being retained but declining very gradually in absolute size (Durndell & Thomson, 1997). Girls generally take fewer computer classes, especially programming classes, and spend less time working with computers in school (Bunderson & Christensen, 1995). They get less help from teachers, because boys tend to dominate both teachers' time and resources (Joiner et al., 1996).

Gender differences in enrolment in school computing courses appear to be reflections of gender differences in attitudes to computing, and/or computing experience rather than differences in computing ability (Campbell, 1992; Jones & Clarke, 1995). Girls are more likely to drop out of computer courses and Bunderson and Christensen (1995) reported that a key factor influencing the high rate of female attrition is lack of previous experience with computers before entering the program. It would seem that the gender gap problem is a compounding one with girls obtaining less computer experience at school partly due to their lack of experience at home and at school.

Boys' greater experience in the use of computers is one of the biggest single factors that leads to gender differences in attitudes to the use of computers (Jones & Clarke, 1995). When experience is controlled, gender differences may disappear. For example, Colley, Gale, & Harris (1994) reported that males were more likely to have used computers at home than females and that males had lower computer anxiety, higher confidence and greater liking than females. When the effects of prior experience and gender stereotyping were removed, however, no significant sex difference on these measures remained. Greater experience was associated with lower anxiety for both sexes, with higher confidence for males and greater liking for females (Colley et al., 1994).

As a consequence one strategy, aimed at developing more positive computer attitudes in girls, is to encourage them to use computers more. Females view the computer more as a tool than males (Hall & Cooper, 1991), and this type of computer use should be encouraged. Girls also need diversity of experience as boys' superior attitudes to computers may be the result of not only more computer experience, but a greater diversity of computer experience. Jones, Farquhar and Surry (1995) found that diversity of computing experience was the strongest predictor of high school girls' attitudes to computers.

Stereotyped Attitudes

Another possible explanation for the gender difference in computer use and attitudes may lie in the stereotypical attitudes held by students. Boys tend to hold more stereotyped attitudes about who is capable of using computers, seeing themselves as more able (Levin & Gordon, 1989; Martin, 1991; Shashaani, 1993; Francis, 1994). Girls are less likely to hold negative stereotypes (Shashaani, 1993; Colley, Hill, Hill & Jones, 1995), and have been shown to have stronger feelings of gender equity

(Makrakis & Sawada, 1996), however, girls are likely to be deterred from computer activities because of the attitudes of the boys.

Self-socialisation processes play a central role in the establishment of stereotypical attitudes. Once children realise that their status as males and females is permanent (they become aware that they are gender constant), they will be motivated to master the behaviours and attitudes typical of gender (Kohlberg, 1966). Both boys and girls quickly learn what is typical for their gender. This gender constancy and gender knowledge combine to influence computer attitudes. Gender constant girls with high levels of gender knowledge like working with computers less than students in other gender constancy/knowledge groups (Newman, Cooper & Ruble, 1995).

Perceived Usefulness

The perceived usefulness of computers does affect people's attitudes to them and the way computers are used. Males continue to report higher scores for the usefulness of computers (Makrakis & Sawada, 1996). Females were more likely to describe the computer in terms of function and view the computer more as a tool than males (Hall & Cooper, 1991). Males are more likely to use nouns and terminology, often talking about the machine itself rather than what it can do. Males tend to see a computer as a machine that extends their power and get excited about the hardware, while females approach the computer more relationally, seeking ways to use the computer (Wiburg, 1995).

For girls to have positive attitudes to computers they need to see a way in which the computer will be useful and interesting. The software used on the computer plays a large role in establishing its usefulness. Particularly for girls, performance is influenced by software, how much the software interests them, and how useful it appears to be (Joiner et al., 1996). In school, computer activities may hold little appeal to females because they do not see any personal relevance to their present or future lives (Makrakis, 1993).

Attributions

Girls tend to show a pattern of learned helplessness in computing (D'Amico et al., 1995). Even though their achievement may be the same, girls may view their performance differently from the way boys perceive their performance. Girls tend to ascribe their success to luck or effort, and when they fail, they are more likely to identify task difficulty or ability as causes. Girls also have lower expectations of success and are more likely to blame their own abilities for failure. Girls are less likely than boys to continue working when the task becomes difficult. Boys on the other hand, are more likely to ascribe success to ability and failure to bad luck (D'Amico et al., 1995). The learned helplessness orientation of girls is especially strong for subjects that are considered part of the male domain. In Mathematics, girls attributed success to effort and failure to ability, while in Language Arts, they attributed success to ability. A similar effect is observed for computing, as it is often viewed as a male domain.

Associations with male-oriented subjects

Computing is often associated with male oriented subjects such as Mathematics and Science and may be influenced by student anxiety in these subjects. For instance, Beamish (1988) found that attitudes to Science were directly related to attitudes to computers. Mathematics liking and mathematics confidence are positively associated with computer interest and computer confidence (Shashaani, 1995). Since many students associate computer technologies with the 'masculine subjects' of Mathematics and Science, negative attitudes hinder many women from participating in computing (Shashaani, 1995). Girls consistently report that computers, mathematics and sciences were the subjects which they liked least and languages were the most liked (Makrakis & Sawada, 1996). The association between mathematics, science, and computing is easy to make. Reinen and Plomp (1993) reported that 99% of computing teachers also teach another subject: 43% also teach mathematics, 14% also teach science. Added to this is the fact that when computers are used in the wider curriculum, it is usually within mathematics and science subjects (Reinen & Plomp, 1993).

Parental attitudes

Use of computers among students is influenced by their parents' interest in what they learn (Clark & Chambers, 1989). Most parents have gender-stereotyped beliefs about their sons' and daughters' computer competencies and parents provide their sons with more opportunity to gain computer experience (Nelson & Watson, 1991). Parents also play an important role in developing students' attitudes (Shashaani, 1994). There is a strong relationship between students' computer attitudes and their perceptions of their parents' attitude toward computers (Shashaani, 1993; Shashaani, 1994). The perceived views of mothers and fathers positively affected their sons, but negatively affected their daughters in all aspects of computer attitudes (Shashaani, 1994). Modelling computer use in the home is also important. As discussed earlier (p 43), the attitudes of both males and females were more positive if they had a brother who used computers, but the influence of the father's use was positive for males only, while the influence of mother's use was positive for females only[3] (Makrakis, 1993; Colley et al., 1994).

Socialisation patterns

Research into the use of computers in schools has reported significant social facilitation effects (Corston & Colman, 1996). Although overall males performed tasks significantly better than females, there was found to be a significant gender by audience interaction. Females performed much better in the presence of a female audience than alone or with a male audience (Corston & Colman, 1996). One explanation for this may be the kind of interaction females encounter when using a computer. Females use facial expressions, smiles, gestures, head movements, and non-verbal movements more often than males (Hall, 1978). When interacting with a computer these components are missing and may result in a different kind of interaction that is not favoured by females (Hall & Cooper, 1991).

The lack of female role models for computing

The gender difference observed in many classrooms may be due to a lack of female role models. In most schools, computer use is dominated by men and there is a general lack of female role models (Reinen & Plomp, 1993). The implication is that working with computers is an activity for men and not for women. It is important that students are exposed to role models from both sexes so that sex-stereotyping may be avoided (Shashaani, 1993).

Summary of Gender Differences

Gender difference is an important presage factor to consider whenever computers are to be used in the classroom. Although the reasons for these differences are complex, given the increasing importance of computers in the classroom and workplace, assisting all students to benefit from these technologies must be a matter of great importance.

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[3] Socio-economic status (SES) also affects children's attitudes to computers. Students from high SES families have more interest in computers. It can be assumed that children from lower SES families have fewer opportunities for access to computers. Overall, parental attitudes substantially overshadowed the effect of SES on children's computer attitudes (Shashaani, 1994).

Student Personality

Student personality may influence the way students work with computers. Vermette, Orr and Hall (1986) found that attitudes to computers reflected personal rather than educational issues. Research suggests that a positive attitude towards computers may reflect a preference for solitary activities and avoidance of social interaction (Hoffman & Walters, 1982).

Eysenck's model of personality (Eysenck, 1947; Eysenck & Eysenck, 1985), maintains that personality differences may be expressed in terms of a small number of higher order factors namely neuroticism, extroversion, and psychoticism. In particular, a higher score on the extroversion scale is described by the test manual as a sociable individual who has many friends, and needs to have people to talk to, and prefers meeting people to reading or studying alone. Although the theoretical basis from which relationships between personality and computer-related attitudes may be hypothesised is not well developed (Francis, Katz & Evans, 1996), and some studies have failed to find a relationship between extroversion and attitude towards computers (Egg & Meschke, 1989; Sigurdsson, 1991; Katz, 1993; Katz & Francis, 1995), there is evidence to suggest a negative correlation between extroversion scores and computer-related attitudes (Bozeman, 1978; Beamish, 1988; Katz & Offir; 1991; Francis et al., 1996).

Student Approaches to Learning

A student's preferred approach to learning is another important presage factor when computers are used in the classroom[4]. Students have many different motives for being involved in computer activities in the classroom. These are important as motivational factors often differentiate between students of comparable intelligence on learning activities (Purdie & Hattie, 1995). Some students show genuine interest, and are intrinsically motivated to learn and progress. Others seem to be motivated by extrinsic factors such as completing a prerequisite for a course, or responding to parental pressure. Whatever the motive, students tend to adopt learning strategies that are

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[4] Although student approaches to learning may change in response to the learning context (Gordon, Lim, McKinnon, and White, 1996), it has been shown that students' preferred approaches to learning are relatively stable over time (Murray-Harvey, 1994). As a result, preferred approaches to learning have been included as presage factors in the current study.

consistent with their motives. The consistency between motive and strategy has led to them being grouped together and labelled an 'approach' to learning (Biggs, 1985).

Three approaches to learning have been consistently identified: surface, deep, and achieving (Marton, 1975; Biggs, 1985; 1987; Entwistle & Ramsden, 1983). Students adopting a surface approach wish to meet institutional requirements minimally. They are motivated by factors that are extrinsic to the real purpose of the task. As a consequence they use strategies that 'satisfice' rather than 'satisfy' task demands (Biggs, 1993). A surface approach tends to be appropriate for recall of unrelated factual detail (Biggs, 1979) but has generally been found to be negatively related to academic performance (Ramsden & Entwistle, 1981; Cantwell & Moore, 1990).

When students have an interest in subject matter they are likely to adopt a deep approach. They then use strategies that are designed to help them discover meaning and maximise their understanding. Students will attempt to engage tasks properly, and while it is not possible to describe the exact strategies that make up a deep approach, as these will be determined by context, students will: possess a great deal of relevant content knowledge, operate at a high level of conceptualisation, act metacognitively, use optimal strategies for handling the task, enjoy the process, and be prepared to invest time and effort (Biggs & Moore, 1993: 312). While the deep approach to learning is associated with higher quality learning outcomes, students using this approach do not always get high marks (Trigwell & Prosser, 1991). Also, students may adopt a deep approach to a subject or task that they are interested in, but may adopt a surface approach to other subjects and tasks. This can lead to an average overall performance at school.

The achieving approach is adopted by those students who wish to obtain a high grade for a task. Students are motivated by the ego-enhancement that results from achieving these grades and consequently use strategies of time management, efficient syllabus coverage, efficient study skills, and others, to ensure high grades. The achieving approach usually relates positively to academic performance and perceptions of performance (Watkins & Hattie, 1990).

The effects of the three approaches to learning are summarised in Table 3.2. All three approaches are general in nature and what they mean in any specific situation depends on the task and the context of learning (Biggs, 1993). They each tend to produce a particular type of outcome. Surface approaches produce outcomes that are rich in detail but poor in structure (Biggs, 1979). Deep approaches produce outcomes that are rich in structure and meaning (Biggs, 1988). Achieving approaches produce institutionally rewarded outcomes (Biggs, 1987).

Table 3.2 Effects of Approaches to Learning

Surface Approach	*Performance*: Poor examination performance, including external examinations, but good for recalling unrelated detail. *Educational*: Intentions to terminate formal education as early as possible; poor academic self-concept; dissatisfied with academic progress; preference for technical rather than science or humanities subjects. *Personal*: An external locus of control (believes that other people and luck determine what happens to you), low verbal IQ, low parental education. Characteristic of younger rather than mature-age students.
Deep Approach	*Performance*: Good performance in external examinations, but only in subjects of interest; learns concepts and principles of high structural complexity with which to interpret detail. *Educational*: Intention to continue formal education to tertiary level; good academic self-concept, sees oneself as good performer and satisfied with progress. Often a preference for humanities, then science subjects. *Personal*: Internal locus of control (believes one controls one's own destiny), but unrelated to IQ (allowing for higher performance in particular subjects), students with a bilingual background tend to have a deep orientation, as do mature-age students and adults.
Achieving Approach	*Performance*: Tends to do well in examinations and generally 'cue seeks' to maximise on what is required for high grades. *Educational*: Intends to stay in formal education to seek the highest qualifications. Sees oneself as a good performer relative to others, but tends to be dissatisfied unless performing at the very top. Preference for science subjects. *Personal*: Internal locus of control, over-achieving (performs beyond what intelligence level would predict - bright, but not the brightest); like deep, related to experience and bilingual background.

(Biggs & Moore, 1993: 320)

Of the three approaches, only the deep approach is task centred. Both surface and achieving approaches reflect learning within an institution and the demands and rewards associated with such. It is not surprising therefore, that problem-based learning in which students are more likely to be engaged in the task is associated with low surface and high deep and achieving (Newble & Clarke, 1986; Biggs, 1991).

The above approaches can be grouped together to give surface-achieving, where the motive is to achieve but the student continues to concentrate on detail, and deep-achieving, where the student is motivated by a real intrinsic interest but also wishes to achieve high grades. The strategies that are adopted by the deep-achiever are usually those that allow an organised and strategic search for understanding and meaning and seems to be the approach that maximises learning within school classrooms (Ma, 1994).

Computers and Approaches to Learning

Student approaches to learning may be of importance in the classroom during database activities. While a number of research studies have explored the validity of student approaches to learning (for example, Andrews, Violato, Rabb & Hollingsworth, 1994) and the relationship between student approaches to learning and student classroom performance (for example, Cantwell & Millard, 1994), little research has explored student approaches to learning in the computing classroom.

The present study seeks to extend the theory of approaches to learning into the classroom in which students work with computerised databases. As discussed in Chapter 2, the use of databases may encourage students to use higher order processes. During database activities, students engage in comparing, hypothesising, generalising, and evaluation (Bezanilla, 1992; Lai, 1992). Deep approaches to learning are consistent with the use of these higher cognitive processes (Gordon & Dunshea, 1996) and may assist in the development of critical and analytical thinking, and they may also encourage students to transfer skills (Purdie & Hattie, 1995).

It was argued in Chapter 2 that the use of databases may encourage students to act metacognitively. Since the early 1970's there has been considerable research carried out that investigates how students make use of their metacognitive abilities. Moore (1991), Volet (1991), Butler and Winne (1995), Ertmer and Newby (1996), Boekaerts (1997), and Veenman, Elshout & Meijer (1997) are all examples of reported research that has investigated the relationship between metacognition and student learning. Biggs and Moore (1993: 310-315) explain the surface, deep, and achieving approaches to learning in terms of student's use of metacognition. Students using a surface approach may show evidence of metacognition and select strategies that help them meet their goal of passing with a minimal amount of effort. More often though the surface approach is favoured by students using little or no metacognitive processes. The main aim of the student is to get the task over and done with and this prevents extensive planning, monitoring, and evaluation of a task. The deep approach is very different. As the students have an intrinsic interest in the subject and are motivated to fully engage in tasks, they are more likely to employ metacognitive strategies. Students adopting the deep approach are more likely to spend time planning, monitoring their engagement in the task, and evaluating outcomes.

In a similar way, the achieving approach usually involves a high degree of metacognitive strategy use. Using the achieving approach students have a good awareness of self, task, time, and resources and spend time planning to maximise the return for effort in each one of these areas. They are influenced to a greater extent by the context in which learning is to occur. If they have a teacher that rewards detail they may adopt surface strategies, however, if the teacher rewards deep understanding they are more likely to adopt and use their full range of metacognitive abilities. Biggs (1987) notes that a deep-achieving approach makes use of a planned and cost-effective search for meaning and is characteristic of many of the better students. This is not surprising as the deep-achieving approach places a large emphasis on planning, monitoring, and evaluation, and hence students engage more fully in true metacognitive experiences.

As students work within the database environment, it would seem beneficial for them to adopt deep and achieving approaches as they attempt to discover meaning from the data that are stored within the database. In this way, students are more likely to make use of higher order processes and metacognitive strategies as they engage in learning. As working with databases most often requires searching for meaning within the data, surface approaches that centre on rote learning are usually unsuccessful. Teachers need to encourage students to adopt deep and achieving approaches through interesting learning activities, appropriate assessment, and the establishment of an appropriate learning context in which students can work and learn.

Various background factors have been found to be related to students' approach to learning. These have included conceptions of learning, ability, locus of control, parents' education, bilingual experiences, and experience in school (Biggs & Moore, 1993). Within the context of the present study, the last of these factors is of particular interest. Deep and achieving approaches have been found to decrease from year 8 to year 11, and in boys more than girls (Watkins & Hattie, 1990). However, deep and achieving approaches have also been found to be associated with students' enjoyment of school, perceptions of school as useful and teachers as fair (Watkins & Hattie, 1990; Biggs, 1993). It would seem that teachers may be in a position to encourage students to adopt deep and achieving approaches through the establishment of an appropriate environment in the classroom.

In summary, approaches to learning recognise the confluence of motive and strategy during learning. Surface, deep, and achieving approaches to learning have been identified by a number of studies as a means of classifying approaches. It is suggested that during computing activities, students should be encouraged to adopt deep and achieving approaches. In this way, students are more likely to make use of higher-order and metacognitive processes as they engage in learning.

Flexibility in Learning

A student's flexibility in learning may be another important presage factor in the computer classroom. Learning involves students in decision-making, particularly with respect to selection of strategies for the task at hand. They must decide how content is to be addressed and how to self-regulate their learning activity (Butler & Winne, 1995). Dyne, Taylor, and Boulton-Lewis (1994) argue that student learning strategies are better classified according to whether they are 'task-appropriate' or 'task-inappropriate', rather than by the terms of 'deep' or 'surface' strategies. As some strategies are likely to be more successful than others in a given situation, students need to be able to select appropriate learning strategies. Students who continue to select only certain strategies, particularly using surface approaches, lack flexibility in their strategy selection and use. This may affect the success of their problem solving endeavours. The way that students go about self-regulating their learning through the selection and monitoring of strategies is important and recently these processes have received a great deal of interest (Boekaerts, 1997).

Self-regulation has been defined as 'the process whereby students activate and sustain cognitions, behaviours, and affects, which are systematically orientated toward attainment of their goals' (Schunk & Zimmerman, 1994: 309). It has become an important construct in understanding effective learning (Winne, 1995). Self-regulated learning is a complex process involving both cognitive and motivational factors

(Schunk, 1995; Zimmerman, 1995). Cantwell (1994) illustrates the self-regulatory dimensions of learning by describing a hierarchy of cognitive and control processes (Figure 3.2).

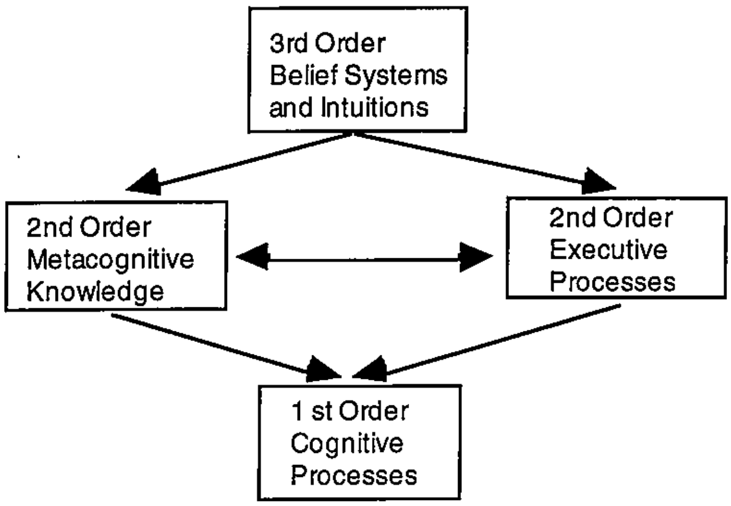

Figure 3.2 1st, 2nd, and 3rd Order Regulatory Systems

First order processes contain the basic content and procedural concerns of the learner. They include declarative knowledge, including facts, concepts, vocabulary, and other bits of information that are stored in memory. This is combined with procedural knowledge generated when students combine, incorporate, or assimilate declarative knowledge so that it can be used procedurally.

Second order processes contain the more proximal control processes that learners bring to bear on specific situations. They contain the motivationally, procedurally, self-regulatory, and volitionally based decisions that determine the course of situation specific learning (Cantwell, 1994). Second order cognitive processes involve both metacognitive knowledge and metacognitive executive processes. Metacognitive skills are important to problem solving and learning (Veenman et al., 1997). Students use metacognitive executive processes to organise an effective working method for the self-regulation of learning (Veenman, 1993). They incorporate both knowledge and self-regulatory dimensions that include control over cognitive processes, and beliefs and intuitions about learning (Schoenfeld, 1987) and include reflecting on the problem, considering the consequences of actions, planning and monitoring, evaluating outcome results, and reflecting on one's learning experiences (Sternberg, 1990; Zimmerman, 1990).

More specifically, learners need to activate knowledge for it to be useful and they use executive processes to perform this task. Metacognitive knowledge is not fundamentally different from other knowledge stored in the long term memory. It is under conditions of 'mindfulness', that metacognitive knowledge is activated (Cantwell, 1994). Students are sensitive to discrepancies between the perceived 'ideal' knowledge state and their perceived 'actual' knowledge state. They act upon discrepancy concerns using second-order constructs to activate a deliberate, conscious memory search for strategies to solve their current dilemma. Selection of cognitive strategies is of great importance in learning. Borkowski and Cavanaugh (1981) claim that metacognition has theoretical importance in so far as it proves useful in explaining variations in strategy selection, implementation, modification, and intervention.

Metacognitive knowledge can also be activated unintentionally and automatically by retrieval cues in the task situation (Flavell, 1979). Usually, metacognitive knowledge is activated under conditions of 'cognitive failure' (Gardner, 1987). Students will search available schema for a potentially successful strategy. It is only when they fail to find a strategy or when an element of the strategy fails that they will call upon metacognitive knowledge. Failures can occur at any time in processing - in planning, monitoring, or evaluation. Learners then make a conscious decision to activate metacognitive knowledge (Cantwell, 1994).

Third order processes contain the more distal control processes. These involve the epistemological, motivational, and volitional assumptions of learning. These control elements operate within the specific contextual demands to specify the form of learning that will take place (Cantwell, 1994). Third order processes largely determine how students react to discrepancies between the perceived 'ideal' knowledge state and their perceived 'actual' knowledge state. They can be considered to be made up of epistemological, motivational/attributional, and volitional/self-regulatory beliefs, and represent the student's understandings and explanations of the causes, nature and implications of discrepancies (Cantwell, 1994).

In summary, the most effective learners self-regulate their learning using a hierarchy of cognitive and control processes (Cantwell, 1994; Butler & Winne, 1995). These students set goals for their learning, deliberate about strategies to select, monitor their learning activities, and manage motivation. During learning activities, impediments may be encountered and learners may have to reassess the situation. They estimate the chance of success if they invest further effort, and may have to adjust or even abandon their initial goals and adapt strategies so that they continue to make progress. Self-regulated learning is a deliberate, judgmental, and adaptive process in which learners are aware of their own knowledge, beliefs, motivation, and cognitive processing. Their goals couple with motivational beliefs and affective reactions to shape self-regulation and assist in the further construction of knowledge (Carver & Scheier, 1990).

Recently there have been calls to consider not only the repertoire of self-regulatory strategies that students possess, but their understandings of how, when and where self-regulatory activity should be called upon (Winne, 1995; Cantwell & Moore, 1996; Cantwell, 1998). To engage effectively in self-regulation students must not only be aware of self-regulatory strategies, but they must also engage in 'mindful' activity. 'Mindfulness' has been proposed as the purposeful way in which learners engage a task that requires effort and self-regulation (Salomon & Globerson, 1987). It has its origins in the higher-order belief systems (Third order belief systems as displayed in Figure 3.2.) and intuitions about the nature, purpose, and goals of learning (Cantwell, 1994). These personal-motivational factors energise the executive skills necessary for effective self-regulation (Chan, 1994). On the other hand 'mindless' engagement in learning reflects a less purposeful, and less effortful, application of routine procedures across domains. These two approaches to executive control over self-regulation have been described in terms of adaptive and maladaptive dispositions towards control over task engagement (Cantwell, 1994).

Cantwell and Moore (1996) found that mindful learners used adaptive executive strategy control with students engaging the adaptive strategies of planning and monitoring. Planning requires learners to reflect on content and strategies prior to engaging the particular task. In a similar way, monitoring requires learners to reflect on cognitive activities as learning progresses (Cantwell & Moore, 1996). Those learners who adopted a 'mindless' approach used maladaptive modes of executive control. In the first of these modes, learners failed to plan prior to cognitive activity and failed to monitor during cognitive activities. In these instances executive control processes are associated with inflexibility in decision-making and control. Students demonstrated this mode of control when they continually attempted to use the same preferred strategy in hypermedia environments, even though there were other more suitable strategies available (Oliver & Oliver, 1996). In the second maladaptive mode, learners recognised the need for executive control, however, they are unable to control the strategic and content decisions required for successful learning to occur. This led to an irresolute form of executive control (Cantwell & Moore, 1996).

The different types of control over task management are associated with different academic performances. Adaptive behaviours are associated with better performance, while both of the maladaptive modes of executive control (inflexible and irresolute) are associated with less successful and poorer quality academic performance (Cantwell & Moore, 1996; Cantwell, 1998).

Databases and Flexibility in Learning

Flexibility in learning may be of particular importance as students work with databases. During database activities students are often asked to work with problems that require responses that cover the entire range of Bloom's (1956) taxonomy. To achieve these outcomes, students perform tasks that require them to classify and categorise information, compare information, formulate, and evaluate hypotheses, generalise, and use Boolean logic (Bezanilla, 1992; Lai, 1992; Maor & Taylor, 1995). Students must be able to use database software and select from strategies that include browsing, searching, sorting, and selecting (Maor, 1993). Students need to be able to construct logical database queries (Bezanilla & Ogborn, 1992) and select appropriate strategies because, although it is possible to manipulate information within a database by using a number of different strategies, not all strategies are as efficient as others.

Within this context it is important that students adapt to the task demands and make use of the adaptive modes of planning and monitoring to help with selection of database strategies. This is very important as the selection of strategies and the quality of the query information is the key to effective problem solving using databases (Bezanilla, 1992). Students need to plan how they can ask worthwhile questions and how to translate their questions into actual search strategies that they can deploy using the database software. They also need to monitor the results as they implement their selected strategy.

Unfortunately many students adopt the inflexible or irresolute maladaptive modes of self regulation. This is evident in the way that many students use only the surface features of a database and continue to manually perform tasks that the computer is able to do more efficiently (Maor and Fraser, 1994). For example, many students continue to use browse strategies rather than using sorting and selecting strategies that would be much more efficient (Bezanilla, 1992). These students are not making use of the full power of the computerised database. There is a tendency to use the computer to do part of the work, leaving some work for the student to do (Bezanilla, 1992). Students who make use of Inflexible or Irresolute modes tend to overlook task specific information strategies in favour of general strategies that may be inefficient and unsuitable for every activity (Oliver & Oliver, 1996).

The ability to self-regulate during database activities seems to have a number of advantages, however, can we expect students in secondary school to self-regulate? It has been claimed that non-experts, including most primary and secondary school students, cannot effectively regulate their own performance as the development of self-regulation is a long term process that takes years to develop properly (Pressley, 1995; Boekaerts, 1997). Several studies do point to an increasing development of metacognitive knowledge as a way of explaining adolescent learners' performance (Pintrich & de Groot, 1990; Schwanenflugel, Fabricius & Alexander, 1994; Pressley, 1995; Winne, 1995). This increase may parallel changes in adolescents' understanding of learning. As children become more proficient users of cognitive and metacognitive strategies, they also develop the capacity to reflect on the strategies available to complete cognitive tasks (Cantwell, 1998). Chan (1994) reported a trend in the development of attributions among children. She reported that children do not fully differentiate effort from ability until early adolescence. These developments in metacognitive knowledge and higher-level attributions during adolescence facilitate the development of self-regulatory control.

What then can be expected of adolescent cognition in secondary school? Cantwell (1998) found that adolescents of 15 and 16 years may not have fully developed higher-level understandings of the nature of self-regulatory control, particularly in relation to the two maladaptive modes of inflexibility and irresoluteness. Cantwell argued that understandings about self-regulation may not crystallise until after individuals separate controllable from less controllable elements of learning. Once learners begin to see effort as being related to enhanced understanding, self-regulatory demands in turn are increased. It may only be then that individuals begin to conceptualise more adaptive from less adaptive modes of self regulatory control (Cantwell, 1998).

As self-regulated learning is effortful, the performance of students forced to engage in self regulation at an early stage, may be negatively effected (Winne, 1995). While adolescent learners may not be able to regulate their own learning adequately, teachers can compensate for a lack of self-regulatory control by providing instructional support during learning activities (Boekaerts, 1997). When using databases, instructional strategies that provide support include scaffolding, modelling, coaching, authentic academic tasks, and cooperative learning (Pressley, 1995). These strategies will be further discussed in Chapter 4.

Prior Knowledge

The prior knowledge that students bring to a learning activity forms an important presage factor (Biggs & Moore, 1993; Derry, 1996). As discussed earlier in this chapter, the past experiences that students have had with computers and databases affect their success in using them. This may be due to the way in which experience helps to build knowledge (Joiner et al., 1996). Many educators view the knowledge base (declarative and procedural) as the single most important condition of expert performance (Sweller, 1991). Learning is cumulative, the more one knows about a topic, and the better organised that knowledge is, the easier, deeper and more enjoyable will future learning become (Biggs & Moore, 1993: 462).

An explanation as to the place and importance of prior knowledge may reside in schema theory. Through knowledge and experience, disparate pieces of information may become integrated into complex cognitive schemata (Audet & Abegg, 1996). The formation of conceptual schemas has been used to explain the difference between expert and novice performance (Derry, 1996). Experts over time construct conceptual schemata through which they navigate with ease because experts not only know more, they have that knowledge organised in more effective ways which enables them to summon information that is relevant to the problem at hand (Audet & Abegg, 1996). Experts can then self-scaffold their knowledge acquisition process and allocate cognitive resources to knowledge extraction and monitoring processes (Boekaerts, 1997).

Particularly when working with information, as is the case in many database activities, the use of schemas and the prior knowledge they contain is important as they free up working memory so that students can self-regulate (Boekaerts, 1997). At the beginning of the learning process the activating of procedural knowledge consumes so much working memory that most of the available resources are expended (Kanfer & Ackerman, 1989). If students are to self-regulate during database activities they need to have procedural knowledge on call to allow them to effectively 'fuse' information processed and information processing (Winne, 1995).

Educators need to be aware of the different types of knowledge necessary for successful completion of different tasks. In particular, a student's prior knowledge can have a large impact on the success of learning activities (Boekaerts, 1997). When working with computerised databases, prior student knowledge has been identified as an important determinant of successful information processing and learning (Ehman et al., 1992). Beamish (1998) identified the various types of knowledge that students use when they work with databases. These include content knowledge of the database, database procedural knowledge, information processing skills, metacognitive knowledge, skills, and control, and motivational beliefs and issues. The last two knowledge types have been considered in the previous section, however, the first three types of knowledge deserve further consideration.

Content Knowledge of the Database

Researchers have investigated the impact of prior content knowledge on the successful use of computers in learning activities. The prior knowledge that students have of the domain in which they are working may affect the success they have in working with databases in that domain. For example, when working with bibliographic databases, a searcher's level of knowledge in the domain in which they are working has been shown to affect the quality of their interrogation of the database (Allen, 1991; Shute, 1993).

Conceptual barriers may also restrict student access to the information contained in other databases. Students may be hindered from accessing information in a database if there are mismatches between their knowledge bases and conceptual structures and those inherent in the database (Bezanilla, 1992; Neuman, 1993). The prior content knowledge that the student brings to the classroom is important as the structure of this knowledge will often determine how well it aligns with the knowledge structure contained within the database (Michel, 1994).

Although some studies failed to find a relationship between knowledge and levels of database interrogation (for example, Chang & McDaniel, 1995), most have found a link between prior student content knowledge and the success of students using databases. Lack of knowledge affects the problem-solving process and students' ability to use a computer database effectively (Ehman et al., 1992). When students were given training in the content of a database, they made better use of the data and took less time to complete a database search (Linde & Bergstrom, 1988; Ehman et al., 1992).

Database Procedural Knowledge

Students benefit from previous experience that builds procedural knowledge of databases (Diem, 1985; Enochs, 1985; White, 1987; Bezanilla, 1992; Maor & Taylor, 1995). Procedural knowledge is important as students with database training tended to solve their problems in shorter time periods than those students that did not (Ennis, 1993; Michel, 1994). Some databases have complex access instructions that have been shown to limit student learning and many teachers assume too much about student database understandings (Ehman et al., 1992). Construction of logical database queries is not a task to be taken for granted (Bezanilla & Ogborn, 1992). Students have been found to experience difficulty in interpreting and constructing logical sentences during database searches, particularly those searches that involve the use of the logical connectors 'AND, OR, and NOT' (Bezanilla & Ogborn, 1992). Students need experience in the use of databases so that they can bring the procedural knowledge necessary to learning tasks. Without this knowledge, students tend to revert to the use of general strategies that may be inefficient and unsuitable for the current learning activity (Oliver & Oliver, 1996). Many teachers do not recognise this and do not have students practise database operations sufficiently before asking them to engage in problem solving and database learning activities (Ehman et al., 1992).

Information Processing Skills

The discussion in Chapter 2 highlighted that databases can be used to help students work with information and develop their higher-order cognitive processes. In particular, students develop skills in analysis, synthesis, and evaluation (White, 1987; Rawitsch, 1988; Degl' Innocenti & Ferraris, 1988; Watson & Strudler, 1989; Langhorne, 1989; Ryba & Anderson, 1990; Bezanilla, 1992; Ehman et al., 1992; Ennis, 1993; Neuman, 1993; Williams, 1994; Maor & Taylor, 1995; Audet & Abegg, 1996; Healy & Hoyles, 1997). Students working with simple databases use the skills that include classifying, comparing, hypothesising, generalising, and using Boolean logic (Bezanilla, 1992). They engage in a number of cognitive processes in which they discriminate information, categorise information, formulate, and evaluate hypotheses (Lai, 1992; Maor & Taylor, 1995).

Information processing skills are important and good strategy users have a variety of general and domain-specific strategies for reaching their goals. Studies have demonstrated a link between the number of strategies students possess and academic performance (Zimmerman & Risenberg, 1997). Many teachers do not allow students to develop information skills through experience before throwing them into work on problem solving and hypothesis development or data exploration (Ehman, 1992).

Teaching Context

Teachers, as well as students, bring presage factors to the learning process. Teaching presage factors include the teachers' perceptions of learning and teaching, their expertise, the curriculum content, and teachers' methods of instruction and their methods of assessment (Biggs & Moore, 1993: 452). Teacher conceptions in many of these areas will depend on their perception of student cognition and learning and will subsequently influence their choice of instructional methods and approaches.

It was beyond the scope of the present study to include all of the teaching presage factors as variables in the study. The database course used during the study, however, provided teachers with the same curriculum content, methods of instruction, and methods of assessment. This database course is discussed in detail in Chapter 6.

Of particular interest to the present study is the teaching-learning processes that occur in the classroom. For students to move towards expertise when working with databases, they need to acquire database content knowledge, knowledge about databases, strategies and skills in database use, and metacognitive strategies and skills. They also need to be motivated to work in the area. Many different methods of instruction have been proposed to achieve these ends. They include direct instruction, modelling, scaffolding and heuristics, situated learning, cooperative learning, and practice (Collins, Brown & Newman, 1989). Although it could be argued that these instructional methods were included in the database course which existed prior to the learning activities and as such are teaching presage factors, the present study is interested in how these instructional strategies interact with students' presage and process factors to influence the learning process. Consequently, these instructional strategies will be discussed in the following chapter on classroom processes and student learning.

Summary

The aim of the present study is to examine how databases can be used to enhance student learning in the classroom. Maor (1993) warns that databases by themselves might not help students acquire knowledge and develop higher-level inquiry skills leading to effective self-regulation. It seems to be the total learning environment, including the role played by the students, the teacher, and the computer, that determines the success of database activities.

The dynamic learning system that exists in the classroom is well represented by the 3P model of teaching and learning (Biggs & Moore, 1993). This model considers that learning in the classroom takes place within a dynamic system and that a wide range of factors may influence this system. These factors are grouped into presage, process, and product factors. Presage factors are aspects of students' and teaching contexts that exist prior to the immediate action in the classroom. These influence process factors, the teacher-learning processes in the classroom, and these in turn influence the product factors, usually thought of in terms of student achievement.

When students work with databases there are many factors that exist prior to the classroom activity that can affect their learning. The student presage factors include computer experience, gender, personality, preferred approach to learning, flexibility in learning, and database knowledge and information processing ability, while the teaching presage factors include the teacher's perceptions of learning and teaching,

teaching expertise, the curriculum content, and teacher's methods of instruction and their methods of assessment.

The following chapter provides a detailed discussion of the instructional strategies used in the course and focuses on the process and product factors of the 3P model. In this way it seeks to further clarify the learning system surrounding the use of databases in the classroom.

Chapter 4

Classroom Processes & Student Learning

Introduction

For some time there have been calls for research into student learning that is centred in real classroom environments (Bredo, 1997). Some of these calls were in response to the failure of information processing theory to take into account the learning environment, and the reasons why students engaged in learning (Mayer, 1996). All learning experiences are situated in a particular context which has a considerable influence on the students' use of learning strategies and consequent learning outcomes (Biggs, 1990, 1996; Clarke & Dart, 1994; Ramsden, 1992; Entwistle, 1991). This influence makes the nature of the learning environment very important. Learning is now considered a product of both within-the-student and within-the-teaching/learning context factors (Dyne, Taylor & Boulton-Lewis, 1994) and studies focusing on student learning need to take a whole complex of factors into account (Bereiter, 1990).

Learning involving the use of computers is no exception. Information technologies may have positive effects on student learning outcomes but this success is related to a number of contextual factors (Johnson, Cox & Watson, 1994). In particular, when computerised databases are used in the classroom, positive outcomes may be related to classroom factors. Because of this, Salomon (1990) called for a systemic approach to research on the use of computers in classroom environments. Consideration needs to be given to the total learning environment surrounding the use of databases in the classroom (Maor & Taylor, 1995). This approach considers the interplay of contextual factors and the way they interact to influence learning outcomes.

As introduced in the previous chapter, the 3P model (Biggs & Moore, 1993) provides a useful theoretical framework of the classroom learning system. This model considers that learning in the classroom takes place within a dynamic system and that a range of presage, process, and product factors may influence this system. The previous chapter reviewed some of the presage factors that may influence learning when students use computerised databases in the classroom. The present chapter will consider the classroom processes that impact upon the teaching-learning process, and the various product factors associated with the use of computerised databases in the classroom.

Classroom Processes

The classroom must provide an appropriate context for effective learning to occur (Biggs & Moore, 1993: 309). Collins, Brown, and Newman (1989) developed a strong argument for the establishment of a rich cognitive environment in the classroom that encourages students to engage in effective learning through the use of a number of classroom processes associated with a constructivist approach to teaching and learning.

The constructivist approach focuses on learners constructing their own understandings within a learning context. Learning involves personal construction of meanings, and learning outcomes depend on the knowledge, purposes, and motivation that the individual student brings to the learning situation (Driver & Bell, 1986). However, in a social sense, students construct their understanding when they exchange ideas, and explore and reinforce their ideas by means of class discussions and negotiations (Solomon, 1987). From the constructivist perspective, student construction of knowledge is facilitated by teachers who provide an environment in which students can clarify their ideas, expose their ideas to conflict situations, and reconstruct their ideas (Hand, Lovejoy & Balaam, 1991).

The first classroom process advocated by Collins et al. (1989) is situated learning. This is the term given to the practice of engaging students in work on authentic tasks (Winn, 1993). Through the use of situated learning educators hope to better connect school subjects to their disciplinary referents and relate conceptual knowledge to situations in which it is used. The second classroom process involves establishing a culture of expert practice in the classroom. In this way educators hope to encourage students to develop a sound knowledge base and make use of higher order and metacognitive skills. The third classroom process involves the use of intrinsic motivation. Students who are intrinsically motivated are more involved in their work, more likely to continue to work on tasks and to adopt deep approaches to their learning and to develop positive attitudes. The last classroom process involves the use of cooperative learning. As students work in groups, success is more likely as they support each other, share the work load, and actively engage in learning.

Collins, Brown, and Newman (1989) also describe the use of several specific teaching methods related to a constructivist approach. These include scaffolding to provide a structure to support student learning, teacher modelling of tasks so that students can observe and build a conceptual model of the processes involved to accomplish the task, and student reflection on the learning strategies that they have used and results they have obtained.

The remainder of this chapter provides a more detailed review of these classroom processes and teaching methods and seeks to extend their application into the computing classroom. After discussing the teaching-learning process, the chapter concludes by considering the product factors associated with the use of databases in the classroom.

Situated Learning

Situated learning is the term given to the practice of engaging students in work on 'authentic tasks' in 'real world' settings (Winn, 1993). Some educators argue that school subjects have strayed too far from their disciplinary referents and that students are taught abstract, decontextualized knowledge and skills (Wineburg, 1989). When conceptual knowledge is abstracted from situations in which it is learnt and used its effectiveness is limited. Theorists argue that knowledge is situated, being in part a product of the activity, context, and culture in which it is developed and used (Brown, Collins & Duguid, 1989). Many students experience problems in utilising the knowledge and skills acquired through formal classroom instruction owing to the decontextualization of formal learning experiences.

Often students are asked to learn facts that are isolated from the contexts in which they derive meaning. Context is important as it promotes connections between knowledge, skills, and experience (Lave, 1988). Learning is the by-product of individuals engaged within contexts in which knowledge is embedded naturally (Choi & Hannafin, 1995). A situated learning definition of learning contends that, as there is an active relationship between agent and the environment, learning must take place during the time the student is actively engaged with a complex, realistic instructional context. Any method that tries to teach abstract concepts independently of authentic situations, overlooks the way understanding is developed through continued, situated use, for example, the development of vocabulary (Brown et al., 1989). Situated learning aims to ground education in the practical world of experience by linking content and context to provide students with more useful knowledge[1].

One way to provide students with an appropriate context for learning is to make use of authentic tasks. These involve learners in activities that practitioners and experts engage in during real problem-solving situations (Wilson, 1993). Authentic tasks are coherent, meaningful, and purposeful activities that represent the ordinary practices of a culture (Brown et al, 1989). The use of authentic tasks helps provide the context which itself provides guidance for the activity by helping students develop a sense of situational intent (Prawat, 1993). In effect, the authentic context both cues the learner to situational resources and serves as an advance organiser for related problem-solving contexts (Harley, 1993). The use of authentic tasks also has important motivational potential (Choi & Hannafin, 1995).

The proponents of situated learning claim that schools do not offer students authentic activities. School activity too often tends to be hybrid, implicitly framed by one culture, but explicitly attributed to another (Brown et al., 1989). Many of the activities that students engage in while at school are not the activities of practitioners and would not be used in real world settings. As a result, success within the classroom often has little bearing on performance in the real world.

The use of authentic tasks also may aid in the transfer of knowledge. Often, formal education emphasises abstract abilities that students are meant to generalise for their use (Lave, 1988; Papert, 1993). Increasingly, however, researchers have suggested that general skills often do not promote the transfer of knowledge (Perkins & Salomon, 1989; Brown & Duguid, 1993). Both knowledge and cognitive skills are highly dependent on the contexts in which they are acquired. Experts demonstrate this when they utilise large amounts of detailed, domain-specific knowledge (Larkin, 1989;

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[1] The most extreme position on situated learning contends that not only learning but thinking itself is situated. In contrast to schema theories in which meaning is stored and retrieved from memory, meaning in situated cognition is generated on the spot through perceiving and acting. Remembering arises through interactions with the environment (Young, 1993).

Perkins & Salomon, 1989). As students work on authentic tasks across domains, they may develop the ability to recognise similarities among different contexts. This provides a basic mechanism of analogical reasoning that is needed to facilitate transfer (The Cognition and Technology Group at Vanderbilt, 1993).

The use of computer technologies have been identified as one way that can assist in the situating of learning (Spiro & Jehng, 1990). The use of computers may assist teachers in designing classroom experiences that are in some way authentic, and planning learning experiences that are situated in the real world. One way that has been suggested as facilitating this is the use of 'Anchored Instruction' in which instruction is anchored in real-world events that are appealing to students, such as a trip or adventure (The Cognition and Technology Group at Vanderbilt, 1990). During these activities, computers are used to process information and solve problems.

Another way teachers can situate instruction so that students are exposed to authentic, real world data is through the use of database technologies (For example, Elder & White, 1989; Duffy & Bednar, 1991; Little, 1995; Oakley & McDougall, 1995). Students are often asked to work with information throughout the curriculum and as a consequence, they need to be able to access, manipulate, and interpret relevant information (Riding & Chambers, 1993; Slater & Beaudrie, 1998). The use of databases, appropriately situated throughout the curriculum, may help students use and develop these skills (Salant, 1990; Lai, 1992). Students become active in information processing, involved in real world experiences and immersed in world happenings (Riggs, 1990). Through the use of databases students can, work with and discover current events, retrieve information, and build critical thinking skills as they plan and refine their search and analyse information they retrieve (Crane, 1993). Students may then learn in meaningful contexts, giving new meaning to many classroom activities (Unia, 1991; Goldsworthy, 1997).

Culture of Expert Practice

Collins, Brown, and Newman (1989) have called for the development of a culture of expert practice in classrooms. The present study is concerned with using databases as a tool to help students work with information. The use of databases is a means to an end rather than an end in itself. Developing a culture of expertise within this context involves students acquiring knowledge and skills about how to work with data, and skills in how to interpret the outcomes of that work. As a result, students should construct knowledge within the domain that they are working. This focus is of great importance to the many subjects that require students to work with information.

To appreciate more fully why Collins and her colleagues (1989) have called for a culture of expertise in classrooms, consider the findings of expert/novice studies. Research focusing on expert and novice practices has been conducted across many domains (Woods, 1988). It is generally accepted that educators should move students in the direction of becoming an expert in their particular knowledge domain, although the level of expertise that needs to be developed is not clear. In studies conducted across various knowledge domains, researchers have found that experts have many traits and characteristics in common, for example, Chase and Simon (1973), using chess configurations; Greeno (1979), in geometry; Chi, Feltovich and Glaser (1981), in physics; Sweller and Cooper (1985), in algebra; and Audet and Abegg (1996), using databases.

Experts have been found to have a highly developed knowledge base. Experts not only possess a greater amount of knowledge, but they categorise and organise information in more complex ways, enabling them to access it more readily (Chi, Glaser, & Rees, 1982; Bereiter & Scardamalia, 1986; Woods, 1988; Audet & Abegg, 1996). While the knowledge of novices is structured around the main phenomena in a domain, experts represent these phenomena in relation to higher-order principles represented in the form of declarative knowledge, procedural knowledge, and strategic knowledge (Rohwer & Thomas, 1989). This characteristic is a compounding one in that, the more experts know, the more they are able to learn, and the more meaningful the learning is likely to be. In essence, what distinguishes experts is that they simply know more than novices and are able to efficiently summon information that is relevant to problems at hand (Audet & Abegg, 1996).

The development of expertise usually involves the confluence of content and strategy through the development of schemas (Prawat, 1991; Cantwell, 1994; Derry, 1996). Experts develop a rich knowledge base incorporating specific content knowledge as well as procedural knowledge. Procedural knowledge comes from applying general cognitive skills in highly contextualised ways. The specific content knowledge is then encoded along with the specific procedural knowledge into a schema. As discussed in Chapter 2, the use of databases may help students construct knowledge and learn specific domain content (Ehman et al., 1992; Lai, 1992; Ennis, 1993; Riding & Chambers, 1993; Maor, 1993; Leader & Klein, 1996; Audet & Abegg, 1996). In this way students who make use of computerised databases during learning activities may be assisted along the road to expertise.

Previous studies support the domain specific nature of expertise, however, the results would also seem to suggest that there is more to expertise than a rich knowledge base and the development of schemas (Woods, 1988). Experts have been seen to operate differently to novices in novel situations with experts spending more time planning, monitoring, and checking problem solutions (Harvey, 1981; Audet & Abegg, 1996). Experts frequently spend more time than novices constructing representations of the problems that confront them (Schoenfeld & Herrmann, 1982; Swanson, O'Connor & Cooney, 1990). Novices typically read a problem statement, embark immediately on a course of action, and persist on that course, while experts spend the bulk of their time analysing the problem and planning their attack, but relatively little time implementing their approach (Rohwer & Thomas, 1989). In novel situations experts compensate for their lack of domain specific knowledge by making effective use of metacognitive skills and general problem solving knowledge. Experts are metacognitively aware and metacognitive skills are widely used (Woods, 1988).

The use of computers, and in particular database software, may provide the environment to facilitate the development of these skills (Williams, 1994). Audet and Abegg (1996) observed that some novices made use of database software to start experimenting with higher order strategies and skills. If this spontaneous action is supplemented by a consistent classroom instructional focus, novices may be in an environment that encourages the construction of knowledge and progression towards expertise.

The activation of higher order mental operations is made possible as the computer relieves learners of low-level, tedious operations and heavy reliance on memory capacity (Salomon, Perkins, & Globerson, 1991). When students work with a computer database they are relieved of the burden of low-level tasks of searching, sorting, and manipulating information and they are left free to concentrate on the higher order tasks of planning, classifying, comparing, hypothesising, generalising, and evaluating (Ryba & Anderson, 1990; Maor & Taylor, 1995). Students also have the opportunity to be more metacognitive as they monitor and reflect upon their cognition due to the immediate feedback provided by the computer. This motivates learners to evaluate their decisions, and reflect upon their progress and goals (Butler & Winne, 1995)[2].

Considering the previous review, in calling for a culture of expert practice Collins et al. (1989) are asking teachers to assist students in developing a sound knowledge base, good general problem solving skills, and metacognitive ability. In this way, students actively involved in the construction of knowledge may be helped to acquire an 'effective working method', and encouraged to become self-regulating through the use of metacognitive skills (Veenman, 1993). These skills can be trained within the context of a domain (Brown & Palincsar, 1989; Volet, 1991; Veenman, Elshout & Busato, 1994; Veenman et al., 1997) and can compensate for novice status. The use of databases in the classroom may help facilitate this process (Williams, 1994; Audet & Abegg, 1996).

Intrinsic Motivation

Collins, Brown, and Newman (1989) have called for teachers to consider the role of intrinsic motivation in learning. Student motivation plays an important role in learning and appropriate motivation is essential for students to engage effectively in self-regulated learning (Dev, 1997). Appropriate motivation involves students expecting success in a valued task (Biggs & Moore, 1993: 258). The value students place on tasks is a reflection of the importance they place on them and intrinsic factors encourage students to value tasks because they are interested in the task activity itself.

Individuals learn best when they engage in learning for their own intrinsic reasons, rather than because they have to. The use of intrinsic motivation in the classroom encourages students to make connections between school learning and interests outside of school, ask questions that go beyond the specific task at hand, and enjoy their work (Stipek, 1993: 77). Students who are intrinsically motivated will continue to work at an assigned task, even though it may be difficult. They are more likely to complete tasks, enjoy the challenge of the activity, and retain the concepts learned (Dev, 1997). Intrinsic motivation encourages students to engage in learning activities and to manage those activities. It often signals high-quality involvement, is self-maintaining, and

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[2] For a more detailed discussion see the section on computers and higher order cognitive processes in Chapter 2.

encourages students to develop positive attitudes to learning activities (Biggs & Moore, 1993: 268).

Traditionally, teachers have used extrinsic rewards to encourage students. Although some authors have provided research supporting extrinsic rewards (for example, Cameron & Pierce, 1994), many authors have argued that extrinsic rewards compromise, and work against, the development of intrinsic motivation in students (Deci & Ryan, 1987; Lepper, 1988; Rummel & Feinberg, 1988; Lepper & Hodell, 1989; Kohn, 1993; Tang & Hall, 1995; Cordova & Lepper, 1996). Students are more motivated if the task is meaningful and one way of accomplishing this is to use authentic tasks that are properly situated in the classroom. One explanation for the decline in student motivation in school which decreases steadily from third grade onwards (Anderman, & Maehr, 1994; Lepper, Sethi, Dialdin, & Drake, 1997) is the decontextualization of instruction in the classroom (Cordova & Lepper, 1996). Teachers often introduce new material in a decontextualized form in an attempt to encourage generalisation of principles (Lave, 1988; Perkins, 1992). Students will have a greater intrinsic interest in classroom activities, however, as they carry out realistic tasks that characterise adult expert practice (Collins et al., 1989). Cordova and Lepper (1996) reported that situating learning activities produced dramatic increases in student motivation.

The present study seeks to maximise student levels of intrinsic motivation during database activities. During the database course, the emphasis is on cooperative group-work rather than external assessment. Although the first few weeks of the course require students to become familiar with database operations, the emphasis during the remainder of the course is on the use of real world data, and authentic tasks (Beamish, 1994). These factors combine to encourage intrinsic motivation in students during database activities.

Classroom tasks also need to be of an optimal level of difficulty (Biggs & Moore, 1993). Students are intrinsically motivated when they are challenged with a slightly 'difficult' situation involving conflict between what they are currently learning and what they already know (Stipek, 1993). Their motivation is largely determined by their expectation of success, beliefs in self-efficacy, control beliefs, and attributions of success/failure (Pintrich, 1994). Tasks that have qualities of surprise, incongruity, and complexity challenge the learner. If they are too easy, or too hard, levels of student motivation will fall (Stipek, 1993). When databases are used in the classroom, teachers may encourage intrinsic interest by actively involving students in information processing activities and giving them an expectation of success. Many teachers do not give students sufficient instruction and practice in using database software before they are expected to engage in problem solving (Ehman et al., 1992). This reduces students' expectation of success and consequently may affect their interest in database activities.

Students' levels of intrinsic motivation when using databases may also be related to the content of those databases. Students have shown a preference to work with particular kinds of data. For example, Todman and File (1991) found that students preferred to work with databases that contained subjective data rather than objective data on pop music records. It would seem that not all information is of the same interest to students. Also, students need to be challenged during database activities and wherever possible placed in control of their learning (Stipek, 1993; Cordova & Lepper, 1996). Teachers need to use databases throughout the curriculum so they are associated with meaningful tasks properly situated in the authentic contexts. This can be achieved when databases are used as a tool to facilitate student research throughout the curriculum (Healy & Hoyles, 1997).

In summary, intrinsic motivation has been shown to enhance student learning. Particularly when using databases in classroom learning activities, teachers may encourage students to be intrinsically motivated by reducing extrinsic motivational factors, allowing students sufficient time to practise database operations, using real world data during authentic tasks, and making classroom tasks meaningful at the optimal level of difficulty. Overall, databases may be used to facilitate learning and encourage student interest in learning activities.

Cooperative Learning

Another important classroom process that contributes towards a rich learning environment is the encouragement of students to work cooperatively with their peers (Collins et al., 1989). As a group, students then learn together to achieve a common goal. Groups may vary in terms of size, structure, gender, and types of collaboration (Light & Mevarech, 1992). In group learning success is more likely, and each member of the group can feel as if their actions contribute to this success (D'Amico et al., 1995). Particularly when using a computer, cooperation may produce some very positive results (Gan, 1994; Healy, Pozzi & Hoyles, 1995).

Before proceeding to a more detailed discussion of cooperative learning in the computing classroom, consider first the background to the use of cooperative learning in the classroom. Cooperative-learning techniques have stemmed from two principal sources: one is cognitive, and the other social in emphasis (Light & Mevarech, 1992). The former emphasises the role of cognitive conflict while the latter emphasises the co-construction of knowledge.

The Cognitive Tradition

The Piagetian tradition emphasises the role of cognitive conflict in learning. Students need to experience inconsistencies to make significant changes to the way they interpret the world and demanding tasks lead the student into cognitive conflict (Piaget, 1985). As students attempt tasks where their current skills and knowledge are insufficient to solve the problem, they are forced to work with inconsistencies and contradictions (Pilkington & Parker-Jones, 1996). The cognitive conflict generated leads children to reflect on their own intuitively derived concepts, compare their ideas with others, and as a result, restructure a new theory that takes into account individual differences (Mevarech & Kramarski, 1992).

The role of cognitive conflict has been acknowledged in computer-based learning tasks. Conflict resolution comprises a large part of student interactions in Logo environments (Nastasi, Clements & Battista, 1990). Pairs outperformed single students on computer-based tasks (Crooks, 1994), and the individuals in pairs that argued more frequently made higher learning gains (Pilkington & Parker-Jones, 1996). Wild (1996) identified that students engaged in three interaction types when working cooperatively on computers: isolated, coordinated, and connected. 'Connected' interactions, where students propose, explain, elaborate, define, question or justify a new idea or observation, were the most frequent in groups. Such interactions were not always cooperative, but confrontational, and required students to engage in conflict resolution to complete the computer tasks (Wild, 1996). Working on computer activities in groups has the advantage of developing skills in the resolution of differences (Cumming & Self, 1991), and engaging individual students in conflict resolution. This does not happen by chance but is the result of social settings that force the elaboration and justification of various positions (Mevarech & Kramarski, 1992). As students working within groups complete tasks, they exchange alternate points of view, justifying these with explanations which might trigger remembering and/or conflict either in themselves or their partner (Pilkington & Parker-Jones, 1996). The social context of the group is extremely important in facilitating these interactions and is the other major emphasis of cooperative learning.

The Social Tradition

Cognitive conflict might be only one of a number of mechanisms underlying learning in the computing classroom (Healy et al., 1995). Knowledge is most often exercised in social contexts (Wild, 1996), and learning using computers is often organised in the context of social interaction (Clements & Nastasi, 1988; Crook, 1994). It is important to recognise the socio-cultural perspective to computer groupwork, where the shared context to verbal interactions shape learning (Wild, 1996). Vygotsky (1978) proposed 'co-construction' as the mechanism for cognitive change. He believed that it is important to place the learner in the zone of proximal development, that is, the learner is placed with others who are capable of reasoning at a more mature level (Pilkington & Parker-Jones, 1996). Although Vygotsky emphasised asymmetric interactions between children and adults, or children and more capable peers, subsequent studies have expanded the theory to include symmetric interactions between homogeneous peers (Brown & Palincsar, 1989; Mevarech, Silber & Fine, 1991).

Rather than emphasise conflict, the social tradition behind cooperative learning using computers emphasises knowledge construction in group settings owing to increased interaction (Underwood, Underwood, Pheasey & Gilmore, 1996), reflective activity and self-explaining (Hartley, 1996; Pilkington & Parker-Jones, 1996), cognitive scaffolding (Light & Mevarech, 1992; Mevarech & Kramarski, 1992), reciprocal peer tutoring (Light & Mevarech, 1992), overt execution of cognitive processes (Light & Mevarech, 1992), and modelling (Hooper, Temiyakarn & Williams, 1995).

Computers and Outcomes of Cooperative Learning

The computer may provide an ideal context for cooperative work (Crook, 1995) as computer tools may serve as social mediators in learning (Salomon & Perkins, 1998). Researchers have suggested the use of cooperative learning in the computer (and other) classrooms facilitates both social-affective and cognitive outcomes (Light & Mevarech, 1992; Cavalier, Klein & Cavalier, 1995). Social-affective outcomes include improvements in student interpersonal relationships (Mevarech et al., 1991; Light & Mevarech, 1992; Mevarech & Kramarski, 1992), student attitudes (Hansell & Slavin, 1981; Johnson & Johnson, 1989; Hooper et al., 1995), and student motivation (Johnson & Johnson, 1989; Slavin, 1990; Light & Mevarech, 1992; Cavalier et al., 1995). Cognitive outcomes include improvement in levels of academic achievement (Johnson & Johnson, 1989; Slavin, 1990; Jackson, Fletcher & Messer, 1992; Light & Mevarech, 1992; Gan, 1994; Cavalier et al., 1995; Hooper et al., 1995; Pilkington & Parker-Jones, 1996), problem solving skills (Howe, Tolmie, Anderson & Mackenzie, 1992; Light & Mevarech, 1992), metacognitive processes (Phelps & Damon, 1989; Light & Mevarech, 1992; Cooper, Atweh, Baturo & Smith, 1994; Nason & Martin, 1994), and creativity (Nastasi & Clements, 1991; Light & Mevarech, 1992; Jessup, Egbert & Connolly, 1996).

Overall, the computer has been proposed as providing the context for genuine interaction leading to cognitive enhancement (Light, 1993; Wegerif, 1996; Jackson & Kutnick, 1996). In a review, Sherman and Klein (1995) reported that while not all studies have revealed significantly higher achievement scores for the cooperative groups, most studies have reported some type of non-achievement results favouring groups. These included choosing more elaborative feedback, spending more time on task, and expressing more positive attitudes about working in groups. Even when they are not significantly better, groups are never worse than individuals (Light & Blaye, 1990). Wild (1996) conducted a study in which students worked in cooperative groups using simulation or word processing software. He found that the largest element of student talk in either group was cognitively orientated and that verbal interactions between students when using simulation software facilitated higher-order thinking. Students working in collaborative writing environments found solutions to a range of writing problems, largely through extensive discussion (Wild, 1996).

Factors that affect Cooperative Learning using Computers

There are a number of factors that may affect the success of computer-based, cooperative learning in the classroom. Simply grouping students without shaping the environment may stimulate few cognitive or affective benefits (Hooper, 1992; Wild, 1996). Positive learning outcomes are contingent upon effective student interaction which is influenced by factors such as task structure, software, rewards, group dynamics, and interpersonal skills (Johnson & Johnson, 1989; Slavin, 1990; Gan, 1994; Wild & Baird, 1996).

One of the important factors that affects the success of cooperative learning using computers is the type and amount of verbal interactions (Sherman & Klein, 1995). The quality of talk between children is a crucial factor in the educational outcome of collaborative work (Howe et al., 1992; Whitelock et al., 1993). Having to use language to make plans explicit, to make decisions and to interpret feedback seems to facilitate problem solving and promote understanding (Light, 1991; 1993). There is a major role for the computer in supporting cooperative learning by providing a context for verbal interaction (Teasley & Roschelle, 1993). Group members can match language and action. The computer then becomes a medium for the facilitation of communication within the group (Jones & Mercer, 1993) enabling students to make greater cognitive gains (Howe et al., 1992).

Not all forms of verbal interactions correlate with improved cognitive abilities. In peer learning, students who teach more often also learn more (Webb, 1989). One possible explanation for this is that the person answering the question has to elaborate on the topic while replying to a question. This elaboration requires the student to clarify their own understanding and delve below the surface structure into the deep structure of the topic (Toumasis, 1990).

Along with verbal interaction, studies have identified keyboard usage as being significantly related to achievement (Wizer, 1995). Programs that involve numerous or complex keyboard entries may deter learning when students work in small groups (Malouf, Wizer, Pilato & Crogan, 1990). Less complex keyboard tasks may simplify interactions with computer technologies and allow students to concentrate on the content of learning as opposed to the computer. Complex tasks that incorporate a strong manipulative element at the keyboard encourage individual dominance rather than group participation (Howe et al., 1992).

One of the foremost considerations when using cooperative learning in the classroom is the structure of the groups. Some authors have argued that the structure of the group does not make any difference to the success of the learning activities (Howe et al., 1992). Others have argued that the structure of the group is critical and students in structured cooperative teams perform better on post-tests, enjoy working in teams, perceive more accomplishment, and display higher levels of social and cognitive interaction than participants who work in unstructured small groups (Cavalier et al., 1995; Hudson, 1996). One of the reasons that some structured groups show better outcomes may be due to a more equal distribution of effort amongst the members of the group. Without equal distribution, some team members may put less effort into the task and rely on the work of other group members. Other more hardworking group members may in turn reduce their effort so that other group members do not take advantage of them (Salomon, Globerson & Guterman, 1989).

Groups should be viewed as social systems and must have mutual regard and be able to manage themselves (Healy et al., 1995). Groups are more likely to operate effectively if they are able to develop a framework of structured interdependence together with individual autonomy. Although groups can give an impression of collaboration and rich interaction, many groups engage in low levels of collaboration along with superficial interaction (Atkins & Blissett, 1989). The presence of a 'more capable peer' in a group helps them to engage in more effective learning (Hudson, 1996). 'More capable peers' not only model effective strategies to the other members of the group but they may also act as pupil-teachers to manage the group and coordinate on and off computer activity (Hoyles, Healy & Pozzi, 1992; Hoyles, Healy & Pozzi, 1994).

Group composition is another factor that is important to the success of cooperative learning activities. Studies into group composition have considered group size, group members' ability levels, and the gender of group members. Group size has been found to be critical to the effectiveness of learning with pairs of children being more effective than larger groups (Kutnick & Marshall, 1993). Other work has shown a gender by group interaction. For boys, dyads were found to be the optimal size while for girls, a larger group may be optimal (D'Amico et al., 1995). Being in a group is a positive experience for girls where they can take advantage of the opportunities for cooperation and mutual support offered within a larger group.

Students can also be grouped into homogeneous or heterogeneous groups. Proponents of the homogeneity of cooperative groups claim that learning is more successful when the pairs are equally matched (Pilkington & Parker-Jones, 1996). Other studies argue that cooperative learning seems to be enriched by heterogeneity among group members

(Hooper et al., 1995; Hudson, 1996). Students are more likely to be exposed to diverse cultures, attitudes, and value systems when working in heterogeneous groups than in homogeneous groups. Heterogeneous groups also have important cognitive consequences (Slavin, 1990) as student performance is likely to increase in the presence of a more capable peer (Hooper et al., 1995). However, some suggest that less able students benefit at the expense of their more able partners (Robinson, 1990; Willis, 1990; Mills & Durden, 1992).

Slavin (1993) reviewed 27 studies dealing with ability grouping and found little or no achievement differences between students grouped heterogeneously versus homogeneously by ability. The low ability students, however, did indicate more favourable attitudes toward learning when grouped with students of higher ability. Sherman and Klein (1995) found that high ability dyads outperformed mixed and low-ability dyads. High ability students did not suffer from being mixed with low ability, but low ability performed no better, and high ability students were less confident when in mixed dyads.

One of the reasons for performance differences between various groupings may be the levels of communication that occur within the various groups. There may be better communication between group members of equal ability. Homogeneous grouping may stimulate discussion between the high-ability students but restrict discussion among low-ability groups (Hooper & Hannafin, 1991; Hooper, 1992). Students in homogeneous groups are likely to produce more socially orientated talk than those in heterogeneous groups (Wild & Baird, 1996).

The question of gender balance in cooperative groups has been addressed by a number of studies (Barbieri & Light, 1992; Yelland, 1994; Corston & Colman, 1996; Underwood, Spavold & Underwood, 1996). Different gender dyads produce different patterns of interaction, however, the advantage that boys have over girls is independent of gender grouping (Barbieri & Light, 1992). Girl/girl pairs interact more frequently than girl/boy and boy/boy pairs (Yelland, 1994) and mixed gender pairs outperform single gender pairs (Corston & Colman, 1996; Underwood et al., 1990). One explanation for this may be that mixed pairs do not communicate as well as single gender pairs (Underwood et al., 1990; Howe, Tolmie & Anderson, 1991). The level of communication is important as discussion of the task is directly associated with levels of performance (Underwood et al., 1996).

Cooperative Learning and Computer Software

There are many advantages to working in cooperative groups with computers, however, these advantages may not generalise over all types of software. For example, individuals were found to have a significant advantage over pairs when using drill and practice software (Jackson & Kutnick, 1996). Different types of software encourage different types of interactions and learning outcomes amongst students. Programs that are more 'closed' are associated with greater amounts of explaining while programs that are more 'open' are associated with greater amounts of questioning, assessing, and confirming (Crook, 1994). The more directive or closed software limits the interactions between students working with the computer (Anderson, Tolmie, McAteer & Demissie, 1993). Wegerif (1996) questions this conclusion and argues that the structure of educational activities around directive (closed) software may combine an aspect of directive teaching with exploratory learning, integrating the active construction of shared knowledge by pupils with the teaching and learning of a pre-defined curriculum (Wegerif, 1996).

One explanation for the distinction between open and closed software may be that closed software, such as simulations, adventure games, and CAI programs, generally provide a fixed problem space, while open-ended software allows pupils to construct their own problem space. Clements and Nastasi (1988) noted a significant lower percentage of conflict resolution, rule determination and self-directed activity amongst pupils interacting with CAI software compared to pupils working with Logo, a more open program. Generally, more open programs support cooperative learning (Nastasi & Clements, 1992; Anderson et al., 1993). Databases are an example of an open program that supports cooperative work and encourages group interaction (Hunter, 1987; Watson, 1988; Croft, 1990; Mittlefehldt, 1991; Ehman et al., 1992; Lai, 1992; Oshima, Scardamalia & Bereiter, 1996). Ehman et al. (1992) in a review of eight studies on databases found that students cooperated within and across groups, teach each other, and learn important skills. Students help each other with computer problems, challenge one another to think, clarify instructional tasks, and develop accurate generalisations.

Summary of Cooperative Learning

It would appear from the above discussion that cooperative learning using computers, and in particular databases, has many potential benefits. Teachers should be encouraged to facilitate cooperative learning where it is appropriate in their classrooms. The emphasis on cooperative learning in the classroom is likely to increase in the future. Recent studies of human cognition treat human beings as agents in a distributed cognitive system rather than as independent cognitive systems (Salomon, 1993). Distributed intelligence is defined as a combination of people and computers networked together and supported by software designed to help the overall system carry out activities that require intelligence (Perkins, 1995). This new perspective on human cognition makes tool-mediated cooperative work central to many cognitive processes (Oshima et al., 1996). As yet, the educational system does not have in place distributed intelligence systems, however, as schools increase the emphasis on cooperative learning and cooperative problem solving using 'tools' such as databases, they prepare for such a future (Moursund, 1995: 5).

The previous review had highlighted the benefits of engaging students in peer interaction during computing activities. While many students benefit from cooperative work, participating in these activities does not guarantee the development of effective cognitive strategies and improvements in learning (Volet, 1991). Results are dramatically improved when co-operative learning activities contain cognitive learning embedded within the context of a discipline (Brown & Palincsar, 1989; Collins et al., 1989; Hudson, 1996). For example, Hudson (1996) described how cooperative learning activities were enhanced when group members engaged in a cycle of observation, reflection, recording, discussion, and feedback. Cooperative learning in groups has been facilitated when attention is paid to strategy instruction, and in particular metacognitive strategy instruction (Mevarech & Kramorski, 1992). A discussion of various teaching methods that may be used during strategy instruction, including metacognitive strategy instruction, follows.

Teaching Methods

Teachers have used many methods in the classroom to engage their students in effective learning. The teaching methods used during classroom activities have a large influence on student learning outcomes (Casey, 1996). Among others, Collins, Brown, and Newman (1989) developed a strong argument for educators to use the teaching methods of scaffolding, modelling, and reflection to encourage students to engage in effective learning processes. Each of these teaching methods will now be considered in turn.

Scaffolding

Students often need guidance when they use computers to work with information and solve problems. One way to give them this, and encourage them to be more metacognitively aware, is to provide them with a structure in the form of a scaffold to support their learning (Ehman et al., 1992). Scaffolding refers to the supports that teachers may provide to help students work successfully on tasks that they, as yet, can't manage on their own (Collins et al., 1989). Scaffolds are particularly useful during the initial stages of problem solving (Casey, 1996). As students progress on to more difficult problems, the teacher gradually decreases, or fades, the level of the support until students are working on their own.

The concept of scaffolding is founded in the work of Vygotsky (1978), who believed that guided interactions with adults (or more capable peers) could help children develop higher order skills. Vygotsky proposed that the assistance of an adult allowed the child to operate in the 'zone of proximal development', that is, the area where the student cannot proceed alone, but can proceed with the assistance of a more capable other. In a similar way, scaffolding students during problem solving may allow them to proceed where they would otherwise have difficulty proceeding alone.

During problem solving, students who have not developed skills in self-regulation benefit from sources of external regulation that help them to process and integrate new information (Boekaerts, 1997). Task performance for a novice is often a deliberate, step-by-step process of choice and execution based on fairly general strategies (Jong, Ferguson-Hessler, 1996). One type of scaffold that combines general cognitive strategies with the use of a concrete prompt is a heuristic. While general heuristics are not a substitute for domain knowledge and skills (schemas), they can be thought of as devices for retrieving and wielding domain-specific knowledge (Veenman et al., 1997). Heuristics are usually specific to the strategy being taught, yet general enough to allow application to a variety of different contexts (Rosenshine & Meister, 1992). They often make use of an acronym to prompt the stages of the problem solving process (Stokes, 1994).

Researchers have found that this type of scaffolding increases performance on problem solving tasks and increases metacognitive awareness (King, 1991; Rosenshine & Meister, 1992; Day & Elksnin, 1994; Englert, Tarrant, Mariage & Oxer, 1994a; Stokes, 1994; Bielaczyc, Pirolli & Brown, 1995; Cardelle-Elawar & Wetzel, 1995; Mariage, 1995; Scanlon, Deshler & Schumaker, 1996) and heuristics have been used successfully in the computer classroom (King, 1991; Cardelle-Elawar & Wetzel, 1995). In particular, King (1991) used a concrete prompt to guide student questioning during problem solving and encourage the use of metacognitive strategies. She found that, in the computer classroom, students using the questioning guide outperformed unguided questioners, and controls, on both a written test of problem solving and a novel computer task. Guided students asked more strategic questions and gave more elaborate explanations during problem solving than their peers who received no guidance (King, 1991). Cardelle-Elawar and Wetzel (1995) reported that students successfully used the IDEA (Identify, Define, Explore, Assess) model as a self-regulatory strategy to monitor their learning and increase their performance during problem solving using computers. Students were able to assess and predict the outcomes of problem solving and they appeared to achieve greater control of their learning.

The present study aims to use a heuristic to assist students in problem solving as they work with computerised databases. The DEAL (Define the problem, Explore alternative plans, Act on a plan, Look at the results) heuristic was developed to be suitable for year nine students to use during problem solving activities. In using this heuristic, the study sought to combine elements of the work of Bransford and Stein (1984, 1993), who developed a problem solving model represented by the acronym IDEAL (Identify problems and opportunities, Define goals, Explore possible strategies, Anticipate outcomes and act, Look back and learn), the work of King (1991), and the work of Cardelle-Elawar et al. (1992; 1995). In this way it is hoped that students will increase their use of self-explanation and self-regulation strategies, and this will lead to similar performance gains as seen in other studies (for example, King, 1991; Bielaczyc et al., 1995; Cardelle-Elawar et al., 1995).

Modelling

As discussed in the previous section, scaffolding is important during the learning process as it may support students, and help to bridge the gap between their current abilities and independent performance goals. Teachers may use various methods to scaffold students including the use of modelling and think aloud strategies (Englert et al., 1994). Modelling is the least independent and most concrete of scaffolds (Beed, Hawkins & Roller, 1991) and is another way that educators can assist students to develop procedural and self-regulatory strategies. Modelling usually involves teachers performing tasks so that students can observe and build a conceptual model of the processes involved in accomplishing the task (Collins et al., 1989). This requires the externalisation of usually internal cognitive processes so that students are exposed to knowledge that is usually tacit (Collins, 1991). Consequently, modelling that includes cognitive process explanations is more effective than exemplary modelling alone (Johnson, Gutkin & Plake, 1991). This is not necessarily easy for teachers as their own problem solving processes have become automated after years of experience and much of their knowledge is tacit (Volet, 1991).

Teacher modelling has been found to be central to good instruction (Pressley & Harris, 1990; Day & Elksnin, 1994). Teachers demonstrate the use of the strategies in the context of meaningful academic tasks and provide students with 'conditionalised' knowledge, about when and where knowledge should be used (Wilson & Cole, 1992). Consistent use of modelling has long-term positive effects on literacy achievement (Duffy et al., 1986, 1987; Duffy, Roehler, & Herrmann, 1988; Pressley, Rankin & Yokoi, 1996), and writing instruction (Harris & Graham, 1992; Collins & Collins, 1996).

In a similar way, modelling of tasks by teachers is important in the computer classroom (Rowe, 1993: 130). Computer courses in which teachers make use of modelling strategies have significant short-term and long-term effects on students' cognitive and affective learning outcomes (Volet, 1991). In particular, modelling of computer operations and cognitive strategies have been used in classrooms where students work with databases (for example, Maor, 1993: 81). Modelling procedures have been found to be effective in helping children learn interrogative strategies during database searches (Johnson et al., 1991). Also, giving students the opportunity to witness experts' normally covert thinking processes and witness the use of cognitive and metacognitive strategies are important in the development of higher order thinking skills associated with problem solving using databases (Beamish, 1996). It would seem that modelling of database operations not only helps students learn how to use database software, but may also encourage the development of cognitive and metacognitive strategies that are important to the success of problem solving activities that use computerised databases.

Reflection

Reflection is another teaching method advocated by Collins et al. (1989) that may be used to help students develop metacognitive awareness. Reflection is a process that students go through when they stop and think about strategies that they have used and results they have obtained. "Reflection enables students to compare their own problem-solving processes with those of an expert, another student, and ultimately, an internal model of expertise" (Collins et al, 1989: 482). Particularly as students work in a group, the process of reflecting, explaining and justifying strategies and outcomes to someone else promotes learning (Webb, 1989; Hartley, 1996; Pilkington & Parker-Jones, 1996). Reflection is an important metacognitive skill (Flavell, 1976) and leads to increases in student performance (Jacobowitz 1990; King 1991). By engaging in reflective conversations with themselves, and with others, students make sense of their experiences and deepen their understanding (Rowland, 1992).

Reflective questioning may be used effectively when students work with computers (Park, 1995) and particularly when they work with databases (Watson, 1988; Maor, 1993). Benzanilla (1992) in establishing a hierarchy of database tasks found that finding relationships between variables, and subsequently drawing conclusions based on the data, are among the harder tasks that students are asked to perform as they work with databases. This is not surprising as interpretation and evaluation contain aspects that are at the higher levels of Bloom's (1956) taxonomy. The use of reflection may help students as it allows them to negotiate meaning and argue their ideas, and is particularly useful in a whole-class forum (Maor, 1993). By reflecting on the outcomes of their computer-based problem solving, students have the opportunity to review their learning experiences and outcomes actively. They may reflect on their thoughts and assess what they did well and what they failed to do. As students share with their classmates, they may explore what worked for some students, and what other students could try next time. In this way students who found successful strategies could make them explicit for other students (Cardelle-Elawar & Wetzel, 1995). Overall, reflection allows students to evaluate their performance, describe their accomplishments, and their feelings of joy and frustration.

An indication of the importance of having students reflect on their activities is found in the way many studies on scaffolding ask students to reflect and evaluate their performance (for example, Bransford & Stein, 1984; 1993; Enright & Beattie, 1989; Englert et al., 1994; Cardelle-Elawar & Wetzel, 1995; Mariage, 1995; Scanlon et al., 1996). In recognition of this, the present study asks students to reflect during the last stage of the DEAL strategy as they 'Look at the results' of their problem solving. Students are asked to reflect within their cooperative groups, and during whole class debriefings at the conclusion of various segments of the database course. As they share the outcomes of their problem solving efforts it is hoped that they will instruct and encourage each other during the database activities.

The Teaching and Learning Process

Within the 3P model, process factors refer to the teaching and learning processes that interact during classroom instruction. The students' learning processes are based on the interaction between student and teaching presage factors.

> Depending on the students' predilections for a surface, deep, or achieving approach to learning, and depending on how they see the demands made by the teaching context, students clarify their intentions about handling the immediate tasks before them and so derive their particular way of approaching the task in question.
>
> (Biggs & Moore, 1993: 452).

The classroom processes and teaching methods discussed in the previous sections create a learning context and students interpret this context in the light of their own preconceptions and motivations, and derive their own learning processes. These processes are also influenced by the availability of working memory space, whether or not the learner has the procedural knowledge for handling the task in question, and by time constraints. In this way students form their own particular way of approaching the learning task. If educators wish to optimise the learning that occurs in the computer classroom, they need to recognise the dynamic nature of this learning process.

Biggs and Moore (1993: 456) call for teachers to respond to the dynamic nature of the learning process by engaging in 'metateaching', that is, the use of metacognitive processes during teaching. Not all teachers find that creating a rich cognitive environment in the classroom to be easy. Teachers need to be metacognitively aware if they are to properly support and scaffold students during strategy instruction (Biggs & Moore, 1993: 456). Metacognition usually involves planning, monitoring, and evaluation. Teachers need to participate fully in all three activities.

Teachers plan for database activities by selecting appropriate data for students to work with that fits within the curriculum, and by using instructional approaches that enhance both cognitive and social skills. Planning also requires teachers to set goals for individuals and groups within the class, and to decide how they are going to properly evaluate the outcomes of learning.

Once the learning process commences it is important that teachers are actively involved as they monitor and interact with students in the learning environment. Teachers act as managers of the activities, organising rooms and equipment, making sure that students have suitable access to computers. They act as facilitators of the subject matter, and as they are familiar with both the subject matter and database operations, they can support, encourage, observe, and reinforce appropriate behaviours. Teachers also act as guides in the subject matter and learning activities. They may encourage learners to explore the data, and encourage them to ask questions of the database. They help students in their analysis of data and conclusions that they draw. Teachers may also act as participators in the learning process. They model strategies, listen to ideas, take notice of student activities and are interested in their discoveries.

As teachers interact and monitor student activity, they may have to adjust the database activities to maximise student involvement and enhance the learning process. Teachers may only become aware of student presage factors that affect the learning process as they monitor student performance. They then need to move quickly to refine the instructional process to compensate for these factors. This may include the variation of activities, adjusting activities to match the student's pace of performance, monitoring student understanding and revising some activities, reorganising the room to encourage cooperative working groups, and monitoring technical aspects of the database activities. Teachers may also have to refine the database activities so that they better encourage students to adopt deep and achieving approaches to their work. This may mean the removal of extrinsic motivational devices and the encouragement of student curiosity in the data.

Finally, teachers need to evaluate the learning process. Criteria for this evaluation will largely depend upon what teachers expect the products of the learning process to be. This leads to the last stage of the 3P model, that of Product factors.

Product Factors

Product factors of the 3P Model are normally described in terms of learning outcomes. They are important to both students, in terms of perceptions of their own efficacy, and teachers, in terms of how well they are teaching (Biggs & Moore, 1993: 453). Outcomes are reliant upon the different instructional approaches that teachers take in the classroom and are often influenced by assessment. Measures of these outcomes need to take into account not only the amount of knowledge that a student can recall, but also the abstraction of that knowledge. They need to measure higher order abilities such as problem solving ability and metacognitive ability. Unfortunately these abilities are much harder to measure than knowledge recall and are often overlooked. By teachers focusing on more comprehensive measures of assessment, the processes of classrooms may be positively affected with a subsequent impact on learning outcomes.

The learning outcomes of computerised database use in the classroom were discussed in Chapter 2. In summary the use of databases may help students to:

- work with information (White, 1987; Rawitsch, 1988; Underwood, 1988; Watson, 1988; Beek et al., 1989; Downes, 1989; Spavold, 1989; Underwood & Underwood, 1990; Mittlefehldt, 1991; Bezanilla, 1992; Ehman et al., 1992; Lai, 1992; Neuman, 1993; Riding & Chambers, 1993; Maor & Fraser, 1994; Norton & Harvey, 1995; Audet & Abegg, 1996; Leader & Klein, 1996; Oliver & Oliver, 1996; White, 1996).

- learn specific domain content (Rawitsch, 1988; Langhorne, 1989; Northrup & Rooze, 1990; Sheingold & Hadley, 1990; Ehman et al., 1992; Lai, 1992; Ennis, 1993; Riding & Chambers, 1993; Maor, 1993; Michel, 1994; Leader, 1996; Audet & Abegg, 1996).

- develop higher order cognitive processes (White, 1987; Rawitsch, 1988; Degl' Innocenti & Ferraris, 1988; Watson & Strudler, 1989; Langhorne et al, 1989; Ryba & Anderson, 1990; Bezanilla, 1992; Ehman et al., 1992; Ennis, 1993; Neuman, 1993; Williams, 1994; Maor & Taylor, 1995; Audet & Abegg, 1996; Healy, 1997).

- develop positive attitudes (Guttormsen, 1986; Pea & Sheingold, 1987; Downes, 1988; Rawitsch, 1988; Spavold, 1989; Elder & White, 1989; Bezanilla, 1992; Lai, 1992; Benjamin, 1993; Ennis, 1993; Helisek & Pratt, 1994; Maor & Taylor, 1995; Leader & Klein, 1996).

These product factors are important and include both cognitive and affective outcomes. Different aspects of the cognitive outcomes have been discussed earlier in this chapter and again in Chapter 6. Attention is now focused on the affective outcomes as research has established the importance of student attitudes to the success of learning activities that use computers, and student attitudes to computers deserve further consideration.

Student Attitudes to Computers

Student attitudes to the use of computers are important for a number of reasons. Computers are an integral part of the information society in which we live, and participants in our society benefit from their use (Tinkler et al., 1996). Given the increasing importance of computers in the workplace and schools, understanding the role of attitudes to computers is of great practical importance (Schofield, 1995). Attitudes influence students' initial acceptance of information technologies and their future behaviour regarding computers (Selwyn, 1997). This has implications for such things as the future use of computers and choice of careers (Kay, 1990; Busch, 1995).

Secondly, attitudes are important as they contribute to the quality of student life while at school. Young people spend a large proportion of their life at school and the quality of their lives during this time is meaningful, both in itself, and because of its relationship with other outcomes of schooling (Ainley, Reed, & Miller, 1986; Smith, 1996: 167). Schools should be more than just places of academic development, and educators should also be concerned with non-cognitive development in students (Creemers & Scheerens, 1994).

Student attitudes to computers are important as students are being asked to work with computers more in schools. While some research studies have commented on the effect that computers have had on student attitudes to various subjects, few studies comment on the effect of using computers on student perceptions about their school life in general (King, 1995). It has been suggested that computers help increase student enthusiasm for school (Firkin, 1984). Other studies have found that computer use may help improve students' attitudes toward both school and computers (Lever, Sherrod, & Bransford, 1989). King (1995), in a study of student attitudes to computers and school, found that increased exposure to computers in a classroom setting does not necessarily lead to changes in student perceptions of the quality of their school life. He found that factors such as lack of access to computers, and the use to which the computers were put, had a mediating influence on the effect of student attitudes.

Interest in the quality of school life has developed in conjunction with models of student learning that incorporate non-cognitive influences on achievement. Motivational considerations are seen as important as self-regulated learning is a complex process involving both cognitive and motivational factors (Schunk, 1995; Zimmerman, 1995). Self-regulated learning is a deliberate, judgmental, and adaptive process in which learners are aware of their own knowledge, beliefs, motivation, and cognitive processing (Cantwell, 1994). Students' goals couple with motivational beliefs and affective reactions to shape self-regulation and assist in the construction of knowledge (Carver & Scheier, 1990). Students with more positive attitudes to learning are more likely to be motivated to expend effort during the learning process.

> The main thrust of this argument is that students who are happier, more enthusiastic, more engaged in life within schools are likely to learn more and perform better on achievement tests.
>
> (Williams & Batten, 1981: 1)

Finally, attitudes have long been recognised as important predictors of individual differences in learning and achievement (Evans, 1965) and student attitudes to the use of computers in schools are no different (Francis, 1993). Generally, students with negative attitudes to the use of computers do not perform as well as students with positive computer attitudes on computer related tasks (Loyd & Gressard, 1984;

Marcoulides, 1988; Munger & Loyd, 1989; McCormick & Ross, 1990; Okebukola, 1993; Anderson, 1996; Houle, 1996). These results reflect the findings of more general research in which it has been reported that negative attitudes may serve as inhibitors of performance and achievement (Weiner, 1986).

The results of some other studies on attitudes to computers have been less straight-forward[3]. Rather than a positive relationship, Campbell and Williams (1990) reported that computer proficiency was found to be related to the negative attitude of computer anxiety. Levels of achievement may be increased for some students when they are challenged to perform at levels that create a moderate degree of performance anxiety (Stipek, 1988). Also, there is debate as to the causal relationship that links attitudes and achievement. While most studies report attitudes as a predictor of achievement, Knuver, Brandsma, and Hennie (1993) argue that academic achievement should be interpreted more as a cause of attitudes and other affective outcomes rather than the other way round. In this way, attitudes are viewed as 'by-products' of academic achievement.

Predictors of Attitudes to Computers

Several predictors of student attitudes to computers have been identified. Students' previous computer experience has been shown to positively effect their attitudes to computers (Hughes, Brackenridge & Macleod, 1987; Marcoulides, 1988; Kinzie & Delcourt, 1991; Koohang, 1989; Liu, Reed, & Phillips, 1992; Hunt & Bohlin, 1993; Stubbs, 1994; Busch, 1995; Overbaugh & Reed, 1995; Yelland, 1995; Ayersman, 1996). However, studies have shown differing effects depending on the type and quality of these previous computer experiences. As discussed in Chapter 2, many of the previous experiences that students have with computers involve playing games (Doornekamp, 1993; Stubbs, 1994; Downes, 1997) and for many students, home computer use has formed the major part of their computer experiences (Kirkman, 1993). Recreational use of computers has been identified as having a significant positive effect on pupils' enthusiasm for computers (Kirkman, 1993), and is a strong predictor for the attitudinal subscales of liking and confidence (Loyd & Gressard,

[3] The integration of research findings is made complex by the number of different instruments that have been used to measure attitude (Francis, 1993). Within many studies there is no common agreement regarding what computer-attitude scales should measure. Researchers have used at least 15 different measures of attitude to computers (Kay, 1992).

1984; Hunt, 1993; Kirkman, 1993). These experiences may help students establish an expectation of future success and may help to boost self concept (Hunt, 1993; Stubbs, 1994). There is no doubt that these early positive experiences with computers help students to perceive themselves as effective computer users (Yelland, 1995).

Todman and Dick (1993) warned that some attitudes, particularly computer anxiety, may not be fully explained by computer experience. Even if students have had large amounts of experience at home, they may be confronted abruptly with the need to come to terms with computers to meet some specific course demands. Their previous experience may not be reflected in their attitudes within this environment (Todman & Lawrenson, 1993).

Many school experiences, on the other hand, help to build computer confidence in a work environment (Kirkman, 1993). This is important as some home experiences seem to lack the quality of experience that is important. It may be that experience contributes to students' knowledge of computers which in turn affects attitudes (Massoud, 1991). Anderson (1996) argued that it is perceived knowledge rather than experience that is a predictor of attitudes. Students may not be perceiving themselves as being knowledgeable after only playing games. This is supported by Morrison, Gardner, Reilley and McNally (1993) who found that the positive impacts of experience with computers was confined to instances where the pupil's experience could be related to the content domains of their disciplines[4].

Koohang (1987) found that prior computer experience and the nature of computer experience both made a significant difference to attitudes towards computers. Students who had more computer experience showed higher positive attitudes, as did students who were exposed to programming and/or instructional application of computers. In line with these and other studies, experience with databases may help students to develop positive attitudes to computers. As discussed in Chapter 2, students with more database knowledge report more computer confidence. Koohang (1989) argues that student experiences with databases helps them to discover what a powerful tool a computer can be, and successful experience gives students a feeling of control over the computer, and positive attitudes are the result.

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[4] The differences between home and school computer uses are increasing as the software developed for the more lucrative home market is more sophisticated than that developed for schools (Yelland, 1995).

As discussed previously, gender has also been consistently identified as a predictor of attitudes. Many studies report males as having more positive attitudes than females (Massoud, 1991; Todman & Dick, 1993b; Yelland, 1995; Joiner et al., 1996). When using databases, male students perceive the computer as being more useful than females (Koohang, 1989) and the less positive attitudes of females hinder their performance and achievement (Corston & Colman, 1996). From a young age boys are more likely to think that their own gender is better at using computers than girls (Hughes et al., 1987; Siann et al., 1990; Yelland, 1995). However, positive experiences with computers can help to modify these attitudes (Yelland, 1995; Ayersman, 1996). Some studies report no gender differences in attitudes (Hunt & Bohlin, 1993; Busch, 1995; Ayersman, 1996), particularly when previous computer experience is controlled for (Anderson, 1996). Many of these studies are based on results from college age students and point to the role that previous computer experience has had on attitudes (Hunt & Bohlin, 1993; Busch, 1995; Ayersman, 1996).

Overview

The present study is concerned with using computers, and more specifically database management software, to enhance student learning. Chapter 2 reviewed the use of computers in education, and specifically, the use of databases in the classroom. The previous chapter introduced the 3P model and reviewed some of the presage factors that may affect learning when students use databases in the classroom.

The present chapter has discussed the process and product factors of the 3P model and emphasised the importance of a rich cognitive environment in which to conduct database activities. Positive outcomes are achieved when instructional approaches combine cognitive learning strategies with structured co-operative interactions and are embedded within the context of a discipline (Volet, 1991). The review specifically discussed situated learning, expert practice, intrinsic motivation, and cooperative learning activities, as ways of establishing a rich cognitive environment in the classroom. Teaching methods discussed included scaffolding, teacher modelling, and student reflection.

Chapters 2, 3 and 4 combine to provide a theoretical basis for the present study. Attention now turns to the discussion of the general model for analysis. The following chapter discusses the conceptual framework of the study and, from a discussion of the relationships between the specific presage, process, and product factors, the general model for the analysis is developed and the research questions the present study seeks to address are outlined.

Chapter 5

The General Model for Analysis

Introduction

From the literature reviewed, it would seem that databases may assist students to work with information and acquire knowledge. As students work with databases they may develop problem solving skills based on the development of cognitive and higher order thinking skills. Using databases in the classroom may also encourage students to develop positive attitudes to their work and this motivates them to learn. As a consequence powerful learning situations can result (Underwood, 1988).

There are a number of factors that are associated with the successful use of databases in the classroom. As discussed in the previous chapters, these factors may be described using the 3P model (Biggs & Moore, 1993: 448) which divides them into presage, process, and product factors. These three types of factors interact to form a dynamic system in the classroom (Biggs & Moore, 1993: 448) and provide a suitable framework for a discussion of student learning within a computerised environment.

The aim of this chapter is to develop a general model of the relationships between factors of the learning system when students work with computerised databases. The development of specific aspects of this model will allow the identification of research questions and a specific line of inquiry into student learning using computerised databases in the classroom.

Causal Models

Researchers investigating different aspects of learning in the classroom have made use of many types of models to provide conceptual frameworks for their work. One such model that has been frequently used in educational research is the causal model. A causal model seeks to present hypothesised relationships between theoretical constructs. These hypothesised relationships should not arise from data but from theoretical considerations which emphasise the role of knowledge, theory, assumptions and logical analysis in proposing relationships (Pedhazur, 1982: 579). In the absence of a theoretical basis for a model, there are many relationships among variables that can be postulated, limited only by the number of mathematical combinations of relationships that exist (Schumacker & Lomax, 1996: 90). As causal models are meant to increase understanding (Bourke, 1984: 30), relationships included for testing in a causal model should have theoretical importance rather than being included because mathematically they may be shown to exist.

The proposal of causation within a model should not be taken lightly. Some authors argue that causation can be determined only under experimental conditions and that in most classroom research, associations rather than causation, can best be determined (Schumacker & Lomax, 1996: 28). This is not accepted here but it is important to clarify what is meant by causation. Tracz (1992: 880) outlined the conditions for cause and effect to be inferred between variables X and Y:

1. temporal order (X precedes Y in time),
2. existence of covariance between X and Y,
3. control for other causes (eg. Z).

In a discussion of causal models, Bourke (1984: 30-31) argued that although X precedes Y, temporal order is not enough to establish causation. Causation implies that event Y would not occur unless event X occurred and that increases in X cause increases or decreases in Y. Also, one event may not be wholly explained by a single cause but by separate part-causes, each making a particular event more likely even though each is not a sufficient condition of itself to cause the event. Each part-cause can be seen as simply making possible and/or increasing the probability of the event's occurrence.

Reciprocal causation is a special case in which partial contributions are compounded between two events so that it is not clear whether initially X causes Y or Y causes X, or simultaneously each causes the other (Smith, 1996: 61).

Although establishing causation is not a simple matter, the view taken here is that causal models remain a useful analytical device to illustrate the relationships that are hypothesised to exist between variables of interest. These models form the first stage of most structural equation modelling applications and help to identify relationships to be tested, and to guide analysis (Bollen & Long, 1993).

Development of the General Model for the Analysis

The use of databases in the classroom gives rise to a dynamic system of learning. Although many educators have proposed benefits of using computerised databases, it is only when the classroom system as a whole is considered that a fuller understanding can be gained of the way in which learning occurs. Based on the review of the literature, a causal model (the general model for analysis) consisting of the various factors within the 3-P model was established and data were collected to test this model.

The General Model for Analysis (Figure 5.1) presents a schematic representation of the hypothesised relationships between school-, teacher/classroom-, and student-level constructs. As described in Chapter 7, each construct in the model comprises groups of measures recorded using questionnaires, achievement tests, and observation measures. Measures were incorporated into composite variables where possible to provide parsimonious representations of school, classroom, and student effects.

The General Model for Analysis was used to generate detailed empirical relationships in the form of structural equation models. Structural equation modelling techniques were then used to assess the strengths of associations between the variables and constructs in the model. The standardised coefficients of multiple correlation provided by the multilevel analysis program MLn (Rashbash & Woodhouse, 1995) were taken to be the measures of effect size. Unless otherwise noted, the five percent significance level applicable to a two-tailed test was used as the indicator of significance throughout the study.

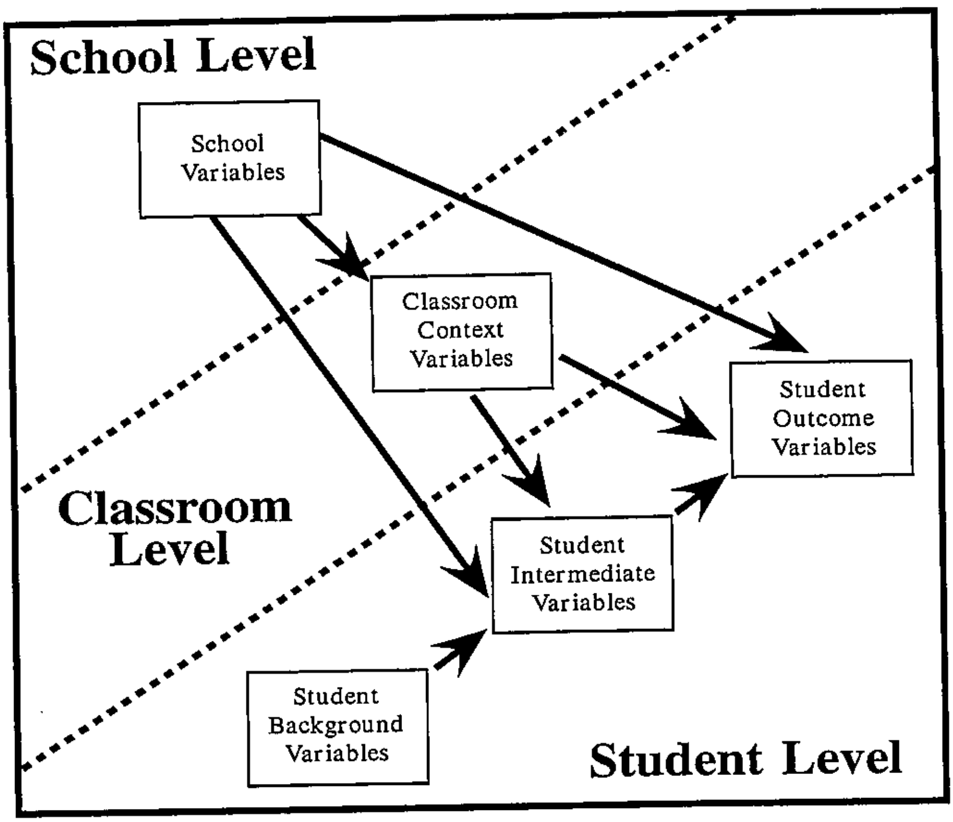

Figure 5.1 The General Model for the Analysis

For most students learning takes place in class groups that are themselves grouped in schools. These groupings are represented in the model by the three hierarchically nested levels in the sample associated with school-, teacher/classroom-, and student-level groups. In general, the pattern of causation flows from the higher-level units to the lower-level units, and from left to right across the model as prior events may influence subsequent events. School effects are thought to directly influence both classroom/teacher and student constructs and indirectly influence student constructs through classroom/teacher effects. Also, presage variables can directly influence process variables and indirectly influence product variables through process variables. Total effect sizes can be considered as the sum of these direct effects and indirect effects operating through intervening variables.

The current study employs the methodology for analysing multilevel causal relationships used in recent school effectiveness studies. In particular, the study seeks to develop multilevel structural equation models that link hypothesised causal factors arising from the various levels (student, teacher/classroom and school) commonly found in educational research. These models include:

- the categorisation of variables according to a context-input-process-output paradigm,
- multilevel data structures at student, classroom and school levels,
- causal chains, including background, intermediate or intervening variables, and outcome variables,
- outcomes variables which include both cognitive and non-cognitive outcomes.

(Creemers & Scheerens, 1994: 125-138)

Programs for the analysis of multilevel data structures allow the explicit modelling of relationships within and between the levels of the multilevel educational hierarchy. Cross-level influences involve higher-level units impacting in some way on lower levels. Those variables that are seen as having a positive cross-level influence over outcomes at a lower level are described as facilitating variables. It is this type of model which provides the framework for analysis in the current study.

The next section defines more fully the variables included in the model, along with the proposed within-level, and across-level, causal paths.

Defining the Constructs

After considering the results of previous studies and relevant conceptual relationships, it was decided that evidence existed to support the inclusion of a range of presage and process variables in a model that attempts to explain the products of secondary students' work with computers. This section provides a short summary of each of the variables included in the model and outlines the paths that are hypothesised to exist in the model. An expanded form of the general model (Figure 5.1) showing some of the proposed relationships is found in Figure 5.2. This figure is different from Figure 5.1 in that there are only two levels shown. The reasons for this are outlined in Chapter 8 in the section entitled 'Stage 1 of the Analysis: Multilevel Effects in the Data'. Some of the variables and constructs have been grouped into blocks for ease of representation in the model.

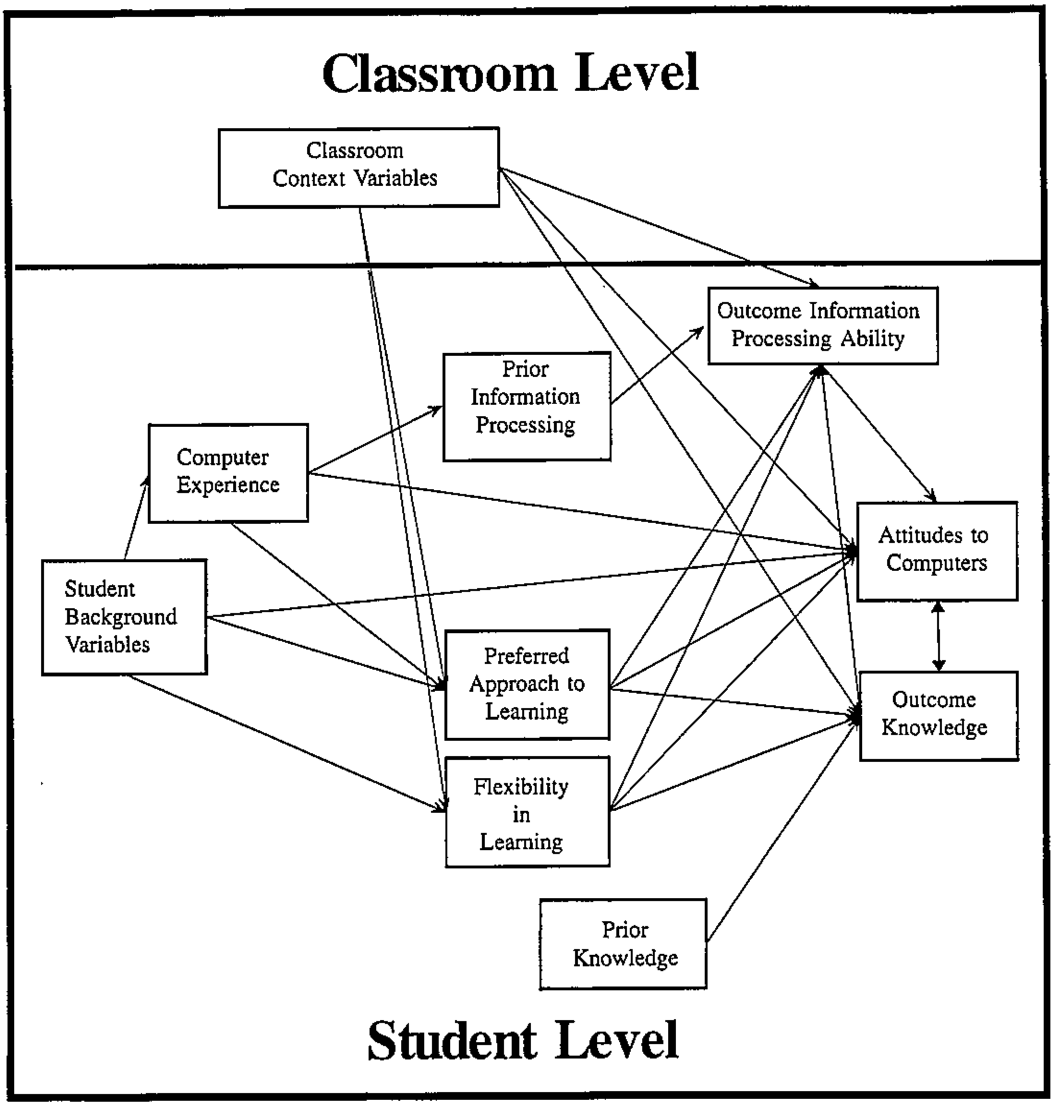

Figure 5.2 Model for Analysis

Student Level Presage Variables

When students work with databases there are many presage factors that exist prior to the classroom activity that can affect their learning. These factors are represented in the model (Figure 5.1) by the Student Background Variables block and the Student Intermediate Variables block. Student presage variables were included in the Student Intermediate block if it could be argued on theoretical grounds that they may be influenced by the Student Background Variables.

Student Background Variables

The Student Background Variables block contains the three variables of Age, Gender, and Personality. Consider each in turn.

Age

As discussed in Chapter 3, the way students use computers changes with age (Downes, 1997). Age had been included as a variable in the model, however, as most of the students included in the present study are of similar ages, it is not expected that this variable will have sufficient variation to be of great influence on process and outcome factors.

Gender

Gender has been identified as an important presage factor. As detailed in Chapter 3 (p45,46) there are clear differences in the ways males and females work with, and relate to, computers. Males are much more likely to have used computers at home and at school at primary, secondary and tertiary levels. Also, boys perform significantly better than girls on computer tasks and studies have found positive relationships between computer experience and problem solving performance. A direct path is therefore hypothesised in the model between Gender and Computer Experience and an indirect path from Gender to Information processing via Computer Experience.

Also, as discussed in Chapter 3 (p46), many studies have found boys to have more positive attitudes to computers than girls. Although some studies have found no gender difference in attitudes, there is little evidence to suggest that girls may have more positive computer-related attitudes or lower levels of computer anxiety than boys. A direct path is hypothesised in the model between Gender and Attitudes to Computers.

A student's preferred approach to learning has been linked to gender and age. As detailed on page 57, deep and achieving approaches have been found to decrease from year 8 to year 11, and in boys more than girls. Also as males generally have more positive attitudes to the use of computers a direct path is hypothesised in the model between Gender and Preferred Approach to Learning.

Personality

Student personality may influence the way students work with computers. Attitudes to computers reflected personal rather than educational issues. As discussed in Chapter 3 (p52), extroversion/introversion are important aspects of personality and there is evidence to suggest a negative correlation between extroversion scores and computer-related attitudes. A small, but significant, direct path is therefore hypothesised to exist between Personality and Attitudes to Computers.

Student Intermediate Variables

The Student Intermediate Variables block contains measures of students' Preferred Approach to Learning, Flexibility in Learning, Computer Experience, Prior Knowledge, and Prior Information Processing Ability. While these variables are all presage variables, they may be directly influenced by the Student Background Variables. Consider each in turn.

Preferred Approach to Learning

Students have many different motives for being involved in computer activities in the classroom. Whatever the motive, students tend to adopt learning strategies that are consistent with their motives. The consistency between motive and strategy has led to them being grouped together and labelled an 'approach' to learning (Biggs, 1985). The Preferred Approach to Learning block contains the three approach variables of Surface, Deep, and Achieving (Biggs & Moore, 1993). Although student approaches to learning may change in response to the learning context (Gordon, Lim, McKinnon, and White, 1996), research has shown that students' preferred approaches to learning are relatively stable over time (Murray-Harvey, 1994).

Although students using a surface approach may show evidence of metacognition, the surface approach is often associated with the student expending a minimum amount of effort and using little or no strategic processes. The deep approach is very different. As the students have an intrinsic interest in the subject and are motivated to fully engage in tasks, they are more likely to expend effort and employ both cognitive and metacognitive strategies. In a similar way the achieving approach usually involves a high degree of effort and strategy use. A direct path is therefore hypothesised to exist between the Preferred Approach to Learning block and the Information Processing Ability block. Also, owing to the intrinsic interest associated with deep approaches, a direct path is hypothesised to exist between the Preferred Approach to Learning block and the Attitudes to Computers block. As discussed in Chapter 3, approaches to learning also influence the knowledge outcomes associated with classroom learning. Consequently, a direct path is hypothesised to exist between the Preferred Approach to Learning block and the Outcome Knowledge block.

Flexibility in Learning

As discussed in Chapter 3 (p57) learning involves students in executive decision-making processes as they self-regulate their learning activities. Effective executive control involves an awareness of self-regulatory strategies and engagement in 'mindful' activity. Students' approaches to executive control over self-regulation have been described in terms of adaptive and maladaptive dispositions towards control over task engagement (Cantwell, 1994). Adaptive strategies include planning and monitoring of cognitive activities, while maladaptive modes include inflexible and irresolute forms of executive control. As the different types of control over task management are associated with different academic performances, it is hypothesised that a path exists between the Flexibility in Learning block and both the Information Processing Ability and the Outcome Knowledge blocks.

As detailed on pages 62 and 63, some authors claim that secondary students may not be able to regulate their own performance effectively, and there is evidence to support an increasing development of metacognitive knowledge as a way of explaining adolescent learners' performance. Adolescents may not have fully developed higher-level understandings of the nature of self-regulatory control, particularly in relation to the two maladaptive modes of inflexibility and irresoluteness. As the sample for the present study draws on students of that age it is expected that the hypothesised paths may not be very strong.

Computer Experience

Computer Experience is included in the model as a composite variable representing different types of experience that include home use of computers, school use of computers, and other use of computers (that is, not at home or school). This variable is expected to cover the entire range of computer experiences available to students.

As discussed in Chapter 3 (p39-41), experiences that students have with computers affect their attitudes to computers and their success in using them. Students with more computer experience report more positive attitudes to computers and are more successful at using them. There is also evidence to support positive relationships between computer experience and problem solving performance, and computer experience and achievement.

Particularly with respect to databases, most studies report a positive correlation between computer experience and attitudes to computers and computer experience and achievement (see page 41). Three direct paths are therefore hypothesised in the model from Computer Experience to Prior Information Processing, Attitudes to Computers, and Knowledge. Also, background experiences, particularly experiences in school, have been found to be related to students' approach to learning (p57). As those students who have more experience using computers usually have more interest in using computers, a direct path is hypothesised to exist from Previous Computer Experience to the Preferred Approach to Learning block.

Prior Knowledge

A student's prior knowledge can have a large impact on the success of learning activities (Boekaerts, 1997). As discussed in Chapter 3 (p63-65), when students are working with computerised databases, prior knowledge has been identified as an important determinant of successful information processing and learning. Particularly the prior knowledge that students have of the domain in which they are working may affect the success of database activities within that domain. A direct path is therefore hypothesised to exist between prior knowledge and outcome knowledge.

Prior Information Processing Ability

Enquiry and information processing skills are important as students work with databases and good strategy users have a variety of general and domain-specific strategies for working with information. As discussed in Chapter 3 (p66), studies have shown a link between the number of strategies one possesses and academic performance. Those students who enter the study with better skills are likely to develop overall superior information processing skills during the database course. A direct path is therefore hypothesised to exist between Prior Information Processing Ability and Outcome Information Processing Ability

Classroom Process Factors

Process factors refer to teaching and learning processes that interact during classroom instruction. Students interpret the teaching context and teaching processes in the light of their own presage factors. They then derive their own learning process as a response to the interaction of the various presage factors and the teaching processes in the classroom. This gives each student their own particular way of approaching the learning task. If educators wish to optimise the learning that occurs in the computer classroom they need to recognise the dynamic nature of the learning process (Biggs & Moore, 1993).

As discussed in Chapter 4, classroom practices that have been shown to help establish a rich learning environment and facilitate student learning include cooperative learning techniques, scaffolded instruction, teacher modelling, and reflection and debriefing. In particular, researchers have suggested the use of cooperative learning in the classroom facilitates both social-affective and cognitive outcomes. Cooperative learning enhances students' attitudes and students working in cooperative groups enjoy high levels of cognitive outcomes which include improvement in levels of academic achievement, problem solving skills, and metacognitive processes (see pages 79-81).

Many studies made use of general heuristics to scaffold student performance. As discussed in Chapter 4 (p87-88), the use of scaffolding increases performance on problem solving tasks and increases metacognitive awareness. Modelling is a form of scaffolding and is one way that educators can assist students to develop procedural and self-regulatory strategies. Teacher modelling has been found to be central to good instruction. Computer courses in which teachers made use of modelling strategies had significant short-term and long-term effects on students' cognitive and affective learning outcomes and modelling procedures have been found to be effective in helping children learn interrogative strategies during database searches (see pages 89,90).

Reflection is a process that students go through when they stop and think about strategies that they have used and results they have obtained for their efforts. As discussed in Chapter 4 (p90), as students reflect in a group, the process of reflecting, explaining, and justifying strategies and outcomes to someone else promotes learning. Reflective questioning may be used effectively when students work with computers and by engaging in reflective conversations with themselves, and with others, students make sense of their experiences and deepen their understanding.

As students worked with databases in the classroom, teachers were encouraged to make use of the teaching strategies and processes described above. These appear as classroom effects in the general model and direct paths are hypothesised to exist between these classroom variables and student level variables. In particular, direct paths are hypothesised to exist between each of these teaching strategies and the student outcome variables of Information Processing Ability, Attitudes to Computers, and Outcome Knowledge.

Student Level Product Factors

Product factors of the 3P Model are normally described in terms of learning outcomes (Biggs & Moore, 1993). As discussed in Chapter 4 (p93-94), outcomes from the classroom use of computerised databases include database content knowledge, database knowledge, information processing skills and positive student attitudes. These outcome variables appear as three block variables in the general model, namely, Knowledge (Content and Database), Information Processing Ability, and Attitudes to Computers.

The better prepared the students with information processing skills, the more they are likely to achieve and the better their attitudes will be to the use of computers (Ehman et al., 1992; Lai, 1992; Ennis, 1993; Maor, 1993). Direct paths are therefore hypothesised to exist between Information Processing Ability and both Attitudes to Computers and Outcome Knowledge.

The nature of the relationship between attitudes and knowledge is of interest in the present study. As discussed in Chapter 4 (p95-96), students with negative attitudes to the use of computers do not perform as well on computer related tasks as students with positive computer attitudes. There is, however, debate as to the causal relationship that links attitudes to computers and achievement. While most studies report attitudes as a predictor of achievement, Knuver et al. (1993) argued that academic achievement should be interpreted more as a cause of attitudes rather than the other way round. In this way, attitudes are viewed as 'by-products' of academic achievement. It is hypothesised that these two blocks have a reciprocal relationship, and as such there will be direct paths from one to the other and vice versa.

Research Questions

From the literature there is considerable evidence that computers, and more specifically databases, can be used to achieve a variety of outcomes in the classroom. The research questions that this study proposes to answer concern themselves with learning outcomes associated with database use in the classroom. They also address the affective outcomes associated with database use, the effect of classroom processes on these outcomes and the relationship between the various outcomes. In particular, the general research questions proposed to be tested are:

1. To what extent did the students learn to use databases during the study?

2. Does the use of computers, and in particular the use of computer database management packages, assist students to acquire content knowledge?

3. Does the use of computers, and in particular the use of computer database management packages, help students to increase their procedural and strategic knowledge as reflected in their information processing skills ?

4. To what extent is learning within the classroom using a database management package affected by presage factors, in particular, the presage factors of: gender, personality, previous computer experience, preferred approach to learning, flexibility in learning, and information processing skills?

5. What attitudes do students have toward the use of computers?

6. To what extent are cognitive outcomes and student attitudes to the use of computers in the classroom related?

7. To what extent are student attitudes to computers related to the presage variables of: gender, age, personality, preferred approach to learning, flexibility in learning, and information processing ability?

8. To what extent are the cognitive outcomes associated with using a database management package, and student attitudes to computers, dependent on classroom process and contextual factors?

Some important subsidiary questions will also be addressed by the study. These will mainly focus on the validation of various instruments used to measure the respective variables involved in the study.

These questions are all posed at the individual student level with the data necessary to complete the study and test the hypotheses being collected by means of student questionnaires, student achievement tests, and the observation of students.

Summary

This chapter has presented the conceptual framework behind the study, defined the variables and constructs included in the General Model for Analysis, and specified the research questions being investigated.

The General Model for Analysis illustrates the hierarchically nested nature of the data characteristic of schools and suggests the need for advanced methods for the estimation of complex structural equation models. The operationalisation of the study, collection of data, and the analytic framework and analysis are discussed in the next chapter.

Chapter 6

Methodology

Introduction

This chapter contains a description of the research methodology employed in the present study to test the model proposed in the previous chapter. It begins with an overview of the research design, and goes on to discuss the development of the database intervention course, the development of testing instruments, and concludes with a discussion of the main study in which the general model was tested.

Overview of the Research Design

The present study investigated the way that computers can be used to enhance student learning and student attitudes to computers. It also investigated various student and classroom factors associated with classroom computer use. The study used causal-correlational methods to test a model that contained hypothesised links between presage factors (student background and intermediate variables), process factors (classroom variables), and product factors (student outcome variables) associated with the use of computerised databases in the classroom.

Year nine was selected for the study as this was the first year that all students in a given year, in all of the schools included in the study, had the option of studying the New South Wales school certificate course in Computing Studies. Although other subjects were considered in which to run the study, Computing Studies was selected mainly for logistical reasons. Students working within this subject have good access to computers and the study of databases forms part of the Computing Studies syllabus.

The study proceeded in three stages. During the first stage, the intervention course on databases was developed and trialed in a single classroom (term three of 1993). In the second stage, a pilot study was conducted in which the database course was trialed in nine classrooms and testing instruments were developed (term four of 1993). The final stage saw the main study implemented in 25 classrooms and data were collected to test the proposed model (term three of 1994). A discussion of each of these three stages of the study follows.

Development of the Database Course

Databases are tools that are potentially of great value to students as they seek to analyse and manage information. However, most students in year nine have not acquired the knowledge, skills, and experience to allow them to use databases to solve problems successfully. Consequently, a course was developed in which students would acquire some of the necessary knowledge, skills, and experience so they could make use of database technologies during problem solving. The aim of the course was to provide students with a rich cognitive environment in which to work with databases and develop information processing skills.

The development of the database course culminated in it being trialed during term three of 1993 in a single class of 28 year nine students who were working within the Computing Studies Syllabus in the Hunter Region.

Background to the Database Course

Adopting a theory based approach to the use of computers in the classroom is of value (Chaiklin, Hedgegaard, Navarro & Pedraza, 1990). Before proceeding to consider the database course in detail, it is important to consider briefly the theories of learning that underpin the use of databases in classroom learning.

Theories of Learning

During the 20th century, psychologists have used three main metaphors of learning: behaviourism led to information processing, which led to constructivism (Mayer, 1996). Behaviourism was based predominantly on research on learning in laboratory animals and viewed learning as the strengthening or weakening of associations between a given stimulus and a given response. The cognitive revolution of the 1950's and 1960's saw a move to the information processing metaphor. The invention of the computer, and analysis of tasks that it could perform, led psychologists to view humans as processors of information (for example, Newell & Simon, 1972). Similar to a computer, the mind was considered an information-processing system and human cognition was thought of as a series of mental processes. According to this view, humans take information as input, apply one or more mental operators to that information, and produce information as output. Learning is the acquisition of mental representations of information, and any cognitive task can be analysed into a series of information-processing stages (Mayer, 1996).

The third metaphor views learning as knowledge construction. Knowledge is not transmitted directly from teacher to student, but is actively built up by the learner through interaction with the environment (Driver, Asoko, Leach, Mortimer & Scott, 1994; Edwards, 1996). The change from information processing to constructivism was in response to the call for ecologically valid research that grounded learning theories in real life learning experiences (Mayer, 1996). While behaviourism focused on the behavioural outcomes with little regard for cognition, and information processing focused almost entirely on thinking and problem solving in isolation, constructivism sought to combine cognition with motivational and environmental issues.

Constructivism

Constructivism is the dominant paradigm in education today (Edwards, 1996). There are several versions of constructivist theory[1] (Prawat, 1996), but despite these variants Noddings (1990) argues that most constructivists would agree that all knowledge is actively constructed, knowledge is organised in networks that are increasingly more complex and abstract, and constructed knowledge is under a nearly continuous state of reorganisation and restructuring.

---

[1] From the 'modern' constructivisms of information processing theory and radical constructivism to the 'postmodern' constructivisms of sociocultural theory.

The various versions of constructivism come from two main traditions in psychology. The first tradition focuses on personal construction of knowledge through personal interactions with the environment. This tradition flows from a Piagetian perspective on personal knowledge construction. Knowledge is constructed by learners who give meaning to new experiences in terms of their prior knowledge and past experiences. The construction of knowledge occurs as a reflective activity in an attempt to make experience meaningful (Edwards, 1996). Learners construct theories about the world that are challenged by external events which lead to changes in those personal theories (Kroll & LaBoskey, 1996). Learners proceed through a cycle of interaction which leads to dissonance which in turn leads to reflection which leads to restructuring which leads back to interaction and so on (Underhill, 1991). Knowledge consists of past constructions and there is no 'true' objective knowledge as one can only know things through one's own logical framework (Fosnot, 1989: 3).

The main pedagogic implication of a personal constructivist perspective is that the learner's construction of knowledge can be facilitated by teachers who challenge student conceptions and involve them actively in the teaching-learning process by providing stimulating and motivating experiences (Driver et al., 1994). This type of pedagogy emphasises that learners need to be actively involved, to reflect on their learning and make inferences, and to experience cognitive conflict (Fosnot, 1989). As a consequence, learning in the classroom would seem to require activities that challenge learners' prior conceptions and encourage learners to reorganise their personal theories.

The second tradition portrays the knowledge-construction process as coming about through learners being engaged in social processes in the classroom and emphasises the social construction of knowledge (Cobern, 1993). From this perspective, learning is regarded as a social activity in which learners are engaged in constructing meaning through discussions and negotiations among peers, students, and teachers (John-Steiner & Mahn, 1996). Students' individual constructions of meaning occur when their ideas are compared, explored, and reinforced in a social setting (Driver et al., 1994; Solomon, 1987, 1991). Through social interactions, students become aware of others' ideas, seek confirmation of their own ideas, and reinforce or reject their personal constructions. This tradition flows from a Vygotskian perspective, with a pedagogical emphasis on processes of enculturation, involvement in cognitive apprenticeships and others (Driver et al., 1994).

Constructivist theories are continuing to develop and there still remains sources of confusion between them. Theoreticians debate the very process of knowledge construction. Is constructed knowledge based on previously constructed knowledge or received knowledge? Are learners discovering an ontological reality or coming to more powerful and coherent understandings of the experimental world (Marshall, 1996)? There is confusion from the use of the same words and metaphors in various theories to convey different or changing concepts (Steffe, 1995; Derry, 1996), and debate continues over the radical constructivist view that external reality, although it may exist, is not directly knowable but can be known as it is experienced (von Glasersfeld, 1995). This view seems difficult to reconcile with the information-processing and cognitive schema theory goal of the novice developing the knowledge base of the expert (Marshall, 1996).

Recently, some psychologists have been attempting to clarify the relationship between the personal constructivist, and sociocultural contructivist perspectives (Phillips, 1995; Cobb & Yackel, 1996; Marshall, 1996; Prawat, 1996). Phillips (1995) in a review of the many different forms of constructivism concluded that they were all complex. They are not single issue positions but address a number of deep problems and as a result of their complexity, the various forms of constructivism can be spread out along several different dimensions or axes. The first axis is 'individual psychology versus public discipline'. At one end, Piaget and Vygotsky are concerned with how individual learners go about the construction of knowledge in their own cognitive apparatus. At the other end, other constructivists focus on the construction of human knowledge in general and the individual learner is of little interest. The second axis is, 'humans the creators versus nature the instructor.' This axis addresses the question: Is knowledge made or discovered? The third axis measures the construction of knowledge as an active process. At one end the activity can be described in terms of individual cognition and at the other end in terms of social and political processes. Furthermore, this activity can either be physical or mental, or again both (Phillips, 1995).

Smith (1995) suggests the use of 'knowing' to indicate the subjective meanings of the individual and the word 'knowledge' to indicate socially negotiated and accepted forms of language. With this distinction, constructivist researchers would have a primary focus on knowing, whereas socio-culturalists would focus primarily on knowledge. This does not imply, however, that constructivists are only interested in the isolated individual or that socio-culturalists ignore individual meaning. Rather, it is a linguistic means of describing the emphasis that researchers from either perspective might fruitfully employ.

Constructivism and Information Processing

Consistent with constructivism, the construction of personal knowledge can best be interpreted from an information processing perspective (Mayer, 1996). Information processing can be thought of as having two views. The first is the literal view of information processing that is tightly tied to the computer metaphor and involves a direct application of the metaphor to human cognition. This view can be criticised, not so much for being incorrect, as for being incomplete. The major shortcoming of the literal information processing psychology was the failure to acknowledge that humans process information for a purpose. Information processing ignored the fact that learning is an active and effortful process. It also ignored affective, and motivational aspects along with social, cultural, and epistemological aspects (Mayer, 1996). In comparison, the second view of information processing involves adjusting the computer metaphor to be more consistent with existing research on human cognition. As educators strive to understand cognition that occurs in educational settings, information processing theory has taken on a more constructivist view and offers many benefits in our attempts to understand learning in the classroom. These include the view that all human beings process information by using a common set of components, insights into how components of the processing system function, and the way that cognitive tools like chunking, rehearsal and maintenance techniques, metacognitive monitoring, and others, can be used to explain personal knowledge construction (Phye, 1997: 52).

Databases and Constructivism

The constructivist perspective places demands on the educational setting that are not always easily met. Information technologies help with these demands because of the way they may be used to build a more intimate, supportive, learning environment called for by the constructivist perspective (Perkins, 1992; Hannafin & Freeman, 1995). In doing so, technology may play a different role in the constructivist classroom than it does in the traditional classroom. Perkins (1992) outlines a framework for the use of technology as a support for learning in a constructivist classroom. Technology can be used as an information resource, a learning tool, or a storage device. There is an emphasis on learning rather than on performance and instruction, and computers do not function as instructional systems but as tools that students use to develop cognitive skills and construct knowledge (Winn, 1991).

Databases may be used successfully within the constructivist classroom to promote student learning (Maor, 1993). They can perform all three functions as outlined by Perkins (1992). They can be used to provide students with diverse and dynamic resources, to create an information rich classroom that facilitates deep understanding, and to store information.

Constructivist environments usually revolve around the use of authentic tasks, collaborative learning, and information-rich resources (Nicaise & Barnes, 1996). Computerised databases may be used to operationalise these strategies. The use of computerised databases may stimulate students to become actively involved in their learning by giving them the tools that they need to manipulate their environment (Morgan, 1996). When teachers use computer software such as databases, learners may take more responsibility for their learning (Vockell, 1989; Fawson & Smellie, 1990) and they are more likely to be actively engaged in learning. As they work with databases, students can spend less time looking for information and more time analysing, reflecting, and developing an understanding (Nicaise & Barnes, 1996). Cognitive activities such as thinking out loud, developing alternative explanations, interpreting data, participating in cognitive conflict, developing alternative hypotheses, the design of further experiments to test alternative hypotheses, and the selection of plausible hypotheses from among competing explanations are all examples of learner activities that may be used during database activities which activate the constructivist learning model (Saunders, 1992).

The database course developed in the present study sought to use databases within a constructivist learning environment. To appreciate better what occurs during these learning activities, the following sections will discuss in more detail the personal construction of knowledge.

Personal Knowledge Construction

To construct their own knowledge, students are required to work with many different types of knowledge. In addition to students' epistemological beliefs, four types of knowledge have received attention: domain knowledge, task knowledge, strategy knowledge, and motivational beliefs (Butler & Winne, 1995). Several authors have proposed frameworks or models that illustrate how these knowledge types are related (for example, Butler & Winne, 1995: 248). One such conceptual framework for organising and relating knowledge constructs has been proposed by Alexander, Schallert, and Hare (1991) (Figure 6.1).

This framework attempts to represent the form and type of an individual learner's knowledge during knowledge construction rather than focusing on the activation of knowledge. Although this framework is only one interpretation of how knowledge types may be related, and others may argue for a different representation (for example, Boekaerts, 1997), Alexander, Schallert, and Hare's framework was used to form the basis of the present discussion owing to the succinct way it represents knowledge types.

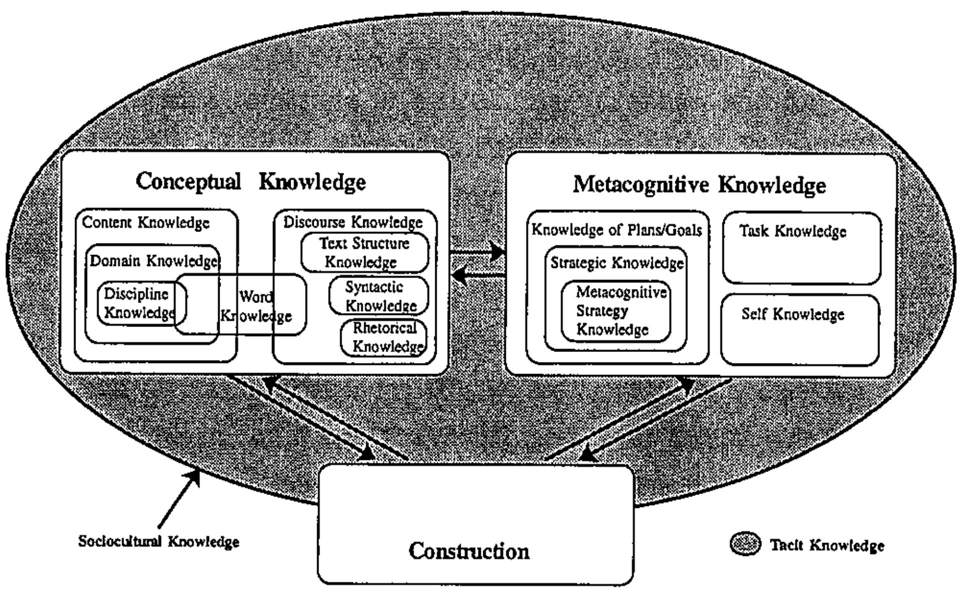

Figure 6.1 Conceptual Framework of Prior Knowledge
(Alexander, Schallert, & Hare, 1991: 324)

<u>Socio-Cultural Knowledge</u>

Socio-cultural knowledge is represented by the oval in Figure 6.1 and is the filter through which all experiences and understandings must pass. It consists of attitudes and beliefs about the world that arise from being a member of a particular culture or social group. It influences the way that individuals will interact with the world in which they come into contact (Pritchard, 1990). Within the sociocultural filter, an individual's knowledge can exist both tacitly and explicitly (Prawat, 1989). Alexander et al. (1991) have acknowledged the fluidity of knowledge in that tacit knowledge underlies the conceptual and metacognitive planes but is not directly part of it. Tacit knowledge, while not directly affecting the learner, may have an indirect or unconscious influence during cognitive activity. When knowledge becomes the 'object of thought' (Prawat, 1989) it changes from being tacit and becomes explicit. Explicit knowledge is represented by the two interacting planes of conceptual knowledge and metacognitive knowledge. These planes interact as they are brought to bear on tasks. A description of each follows.

Conceptual Knowledge

Conceptual knowledge makes up one of the two planes of explicit knowledge. It is static knowledge about facts, concepts, vocabulary, and other bits of information that are stored in memory (Jong & Fergusson-Hessler, 1996). Information at this level can be stored as images or non-verbal knowledge (Phye, 1997), and can also contain procedural knowledge consisting of actions, manipulations, and formulas and rules that are valid within a domain (Boekaerts, 1997; Dochy, 1996). Procedural knowledge can have a specific, domain bound character, or it can be more general (Jong & Fergusson-Hessler, 1996; Phye, 1997).

Alexander et al., (1991) show conceptual knowledge as being made up of content knowledge and discourse knowledge (Figure 6.1). Content knowledge consists of knowledge of some aspect of one's physical, social, or mental world, and contains domain knowledge and discipline knowledge in a hierarchical structure that illustrates a progression of specialisation. Discourse knowledge consists of knowledge about language and its use. At the word level discourse knowledge overlaps with content knowledge since an individual's lexicon has two components. There are the word labels themselves, and the concepts that the labels represent (Alexander et al., 1991).

Metacognitive Knowledge

The second plane of explicit knowledge is metacognitive knowledge. Metacognition is identified as that body of knowledge that relates to the mental processes that organise cognition itself. It involves thinking about and regulating one's cognition, and is often referred to as 'thinking about thinking'. John Flavell (1976) was one of the first to start using the term in the early 1970's.

> Metacognition refers to one's knowledge concerning one's cognitive processes and products or anything related to them... Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete goal or objective.
>
> (Flavell, 1976: 232)

In a similar way, Brown (1978) defined metacognition as a person's knowledge of, and conscious attempts to control, his/her own cognitive processes. She further defined metacognitive knowledge as being made up of two categories. Static knowledge, which is the verbalizable things people state about cognition, and strategic knowledge, which consists of the actual steps that individuals take as they regulate their cognitive activities.

Flavell (1979) expanded his description of metacognitive knowledge to include three sub-categories: task knowledge about the nature of the task, self-knowledge about one's own skills as a cognitive being, and strategic knowledge about the value of different strategies for enhancing cognitive performance. Alexander et al. (1991) have included these three categories in their conceptual framework, along with a fourth: knowledge of plans and goals. The inclusion of such motivational factors as part of metacognitive knowledge is not without its critics. The original definition of metacognition concerned itself with the knowledge of effective strategy use within content domains (Flavell, 1976; Brown, 1978). The subsequent expansion has signified that the term 'metacognitive knowledge' has come to refer to aspects of students' theory of mind, theory of self, theory of learning, and learning environments. Boekaerts (1997) argues that these inclusions are unwarranted as they decrease the explanatory power of the various constructs. She does, however, acknowledge the importance of these constructs as higher order constructs in self-regulated learning.

Alexander et al. (1991) argue that plans and goals are part of metacognitive knowledge. Learners' plans and goals guide the learning process (Stipek, 1993). Research on academic achievement motivation has increasingly focused on students' goals. These include task goals, concerned with developing competence and mastery, ability goals, concerned with demonstrating ability and how one performs relative to others, and social goals, that cover a wide spectrum of beliefs and behaviours, including desires to be popular, socially responsible, altruistic, obedient, and accepted (Urdan & Maehr, 1995). The goals learners set for themselves, and the plans they set for the future, align with how they see themselves, how they judge the importance of the task they are about to undertake, how much energy they are going to expend on the task, and what strategies they are going to deploy. Consequently, goals are important to the success of cognitive activities (Biggs & Moore, 1993). Learning is effortful and goal directed, and goals and plans are an important part of metacognitive knowledge and activity.

Learners use strategic knowledge to implement plans and work towards goals. Strategic knowledge is the knowledge of processes that are consciously invoked to facilitate the acquisition and utilisation of knowledge (Alexander et al., 1991). The use of strategic knowledge helps students organise their problem-solving process by directing which stages they should go through to reach a solution (Jong, 1996). It involves knowing when and how to use declarative, strategy, and procedural knowledge to construct a learning outcome and emphasises the self-directed and volitional nature of learning (Phye, 1997). Strategic knowledge contains as a subset 'metacognitive strategy knowledge' which is knowledge of strategies that allow one to monitor task completion or the attainment of one's goals (Alexander et al., 1991).

For an individual to be metacognitively aware and function effectively during learning it is important that they have an understanding of the cognitive demands of the task at hand. This is represented within metacognitive knowledge as task knowledge. They combine this knowledge with self knowledge, which is the knowledge of themselves as a thinkers and learners, to affect strategy selections (Flavell, 1979; Alexander et al., 1991).

<u>Construction</u>

Construction occurs at the interface of prior knowledge with the current world. It occurs at the point of contact between the learner's prior knowledge and other human processes and is the result of the interaction between existing knowledge structures and information from current experiences (Alexander et al., 1991). The result of construction is the 'instantiation of conceptual knowledge' (Anderson et al., 1976), that is, the development of a model of the physical, social, or mental world that is constructed at the interface or prior knowledge and ongoing processing demands

(Alexander, 1991). This is the moment-by-moment construction of knowledge. As students complete tasks, their knowledge about tactics and strategies is simultaneously constructed and refined along with task knowledge and domain specific understanding (Butler & Winne, 1995).

In summary, learning is a process of knowledge construction. This construction occurs at the interface of a person's previous knowledge and their current experiences. Conceptual and metacognitive knowledge interact to facilitate construction. It is an effortful activity, and the manner in which individuals engage in construction and learning is mediated by higher level, internally constructed control mechanisms (Cantwell, 1994) that include domains of self-regulatory functions and motivational orientations. (Boekaerts, 1997; Snow, 1989).

Databases, Knowledge Construction, and Self Regulated Learning

The use of computerised databases seem to provide opportunities for students to engage in self-regulated knowledge construction (Maor, 1993). It is important, however, to recognise that self-regulated learning is effortful (Winne, 1995) and students are more likely to expend effort when they are confronted with tasks that are challenging, meaningful, and goal directed (Ames, 1992). A student's domain knowledge and interest are two factors that interact to create such situations (Alexander, 1995).

To clarify the relationship between domain knowledge, interest, and self-regulation, Alexander (1996) proposed a model of domain learning made up of the three stages of acclimation, competence, and proficiency. In the acclimation stage, the knowledge that learners have gained is fragmented. Learners are often motivated by situational interest rather than any deep-seated interest in the domain. Because of limited subject-matter knowledge, they rely more heavily on general strategic processing which is not always executed effectively. Attempts at self-regulating learning at this stage place large cognitive demands on learners (Kanfer & Ackerman, 1989). This often leads to a deterioration of performance, especially in low ability learners (Winne, 1995). This does not mean that acclimated learners do not attempt to self-regulate their learning, but rather, self-regulation is less frequent and less rewarding than for those in the later stages of the model (Alexander, 1995). With respect to database use, learners experience the acclimation stage at two stages during database activities. The first is when they are first being introduced to database software and they have not yet internalised database operations. The second is when they are working with a database within a new subject domain. During both of these times learners should not be expected to engage in large amounts of self-regulation.

The second stage of the domain model is the competence stage (Alexander, 1996). During this stage subject-matter knowledge is more extensive and better organised around the key concepts of the domain. Students are increasingly more motivated by domain-related goals rather than task-specific ones and students are more likely to be intrinsically motivated. Because of their greater domain knowledge, competent learners are more able to engage in appropriate strategy use and these strategies are less cognitively demanding. Competent learners are more likely to engage in self-regulation during learning, however, variation in self-regulation does occur due to the developing nature of the domain knowledge. As with all competent learners, those students with a developing knowledge of the use of databases, and a developing knowledge of the domain in which they are used, are more likely to engage in self-regulation than learners in the previous stage. Particularly as database operations become more automatic, less effortful and hence less cognitively demanding, learners are more likely to engage in self-regulation.

Proficiency, the final stage of the model, is typified by learners who possess a large amount of subject-matter knowledge. Also, their activities are characterised by goal-driven behaviour that is driven largely by intrinsic factors. It is at this level that self-regulation during cognition is most likely to occur. Learners are equipped with knowledge and skills to implement motivational and self-efficacy beliefs (Zimmerman, 1995). As with all experts, learners with proficiency in database use are more likely to engage in self-regulation during database activities.

Alexander's (1996) model of domain learning seeks to outline some of the factors influencing self-regulation. Educational psychologists need to expand their views of self-regulation beyond that of a metacognitive trait and recognise it as an interactive process involving social, motivational, and behavioural components (Schunk, 1995; Zimmerman, 1995). Corno (1995) calls for more 'systemic' research that involves the study of practice to provide practitioners with knowledge of how self-regulation functions in real world settings. Barriers to effective teaching and learning exist because students come to perceive learning as the memorisation of facts and formulas, not the self-regulated construction of knowledge and skills for investigating problems on their own (Burbules & Linn, 1991). Schools have been criticised for not empowering students with the knowledge, skills, and interest requisite for full and critical participation in a global society (Shymansky & Kyle, 1991). The use of databases may be one way to help students acquire the necessary knowledge, skills, and interest within the classroom.

Database Course Structure

The database course was designed to assist students to move from acclimation through to competence and it is possible that some students may reach proficiency. Database courses typically progress students through three types of experiences. At first, students learn to work with data in a database created by someone else as they practise searching, sorting and displaying the data. Secondly, they learn to enter and edit data by building a database based on a structure provided by someone else. Finally, they learn to design a database as they create a database structure and fill it with information (Hunter, 1983; Ryba, 1989; Watson, 1988). Many teachers present this approach to using databases by focusing on a particular software package and gradually explain it in more detail in successive lessons. It is, however, incumbent on teachers to provide students with more than a software manual-focused approach to the learning of software packages. Students need to understand the process involved in the application of the software (Little, 1994).

Researchers have identified five basic tools that students need to progress from a novice state to that of expert in any particular area. They are: domain specific knowledge, domain specific strategies and skills, metacognitive strategies and skills, metacognitive executive control, and motivation (Woods, 1988; Audett & Abegg, 1996; Derry, 1996; Veenman et al., 1997). For any database course to be effective, teachers need to provide learning experiences that allow students to progress in each of these five areas. Many courses that use databases have an emphasis on the first two of these five areas, and particularly on the second. Many courses instruct students how to operate a database software package and attempt to give the students domain skills in this area. What they fail to include is an emphasis on problem solving and thinking skills, particularly metacognitive skills. These skills should be an important focus of any information technology syllabus. Teaching the software functions within the context of problem-solving provides the link between theory and practice that students need (Little, 1994). It also increases the level of motivation necessary for students to work successfully (Biggs & Moore, 1993). The course developed for the present study was designed to not only provide students with experience in using databases, but also to help them gain experience in using both cognitive and metacognitive skills. This gives students an opportunity to progress in all areas that are necessary for the development of expertise.

The Course

The New South Wales Computing Studies syllabus is divided into two sections; core and electives. The elective section of the syllabus is divided into six themes. It is within the theme of Information Systems that the database course was developed. There is not meant to be a compartmentalisation of the core and electives within the syllabus, and a systems approach to the study of the syllabus is recommended.

The course materials were developed to be rich in metacognitive experiences. Individual class teachers were responsible for classroom instruction during the teaching of the database course and the course materials encouraged them to use the metacognitive training techniques of direct instruction, peer interaction, scaffolding, teacher modelling, and reflection (Paris & Winograd, 1990; Sawyer, Graham & Harris, 1992; Bransford & Stein, 1984). Consider now the course in more detail.

Course Outline

The course itself builds on the development of previous database courses (Watson, 1988; Ryba, 1989; Lai, 1992) by including an emphasis on problem solving when working with information. It consists of four sections. Section 1 engages the students in exercises that introduces them to databases and teaches them the mechanics of how to use the software and manipulate data contained in a database. Section 2 introduces students to problem solving and hypothesis testing using databases. Section 3 provides the students with a database shell and they build the database file, while section 4 involves the students in a research project in which they create their own database file.

Table 6.1 shows a timetable of the various lessons included in the database course[2] conducted over 10 weeks. The last week of the term was left free to allow for the administration of testing instruments in the main study (see Table 6.4). Each of the main sections of the database course will now be discussed in turn.

Table 6.1 Database Course

Week 1	Introduction Lesson	Introduction to Databases	Database Terminology	Database Terminology
Week 2	Browsing /Layout /Arranging	Browsing /Layout /Arranging	Arranging / Sorting	Arranging / Sorting
Week 3	Selecting Records	Selecting Records	Selecting Records	Selecting Records
Week 4	Selecting Records (find/sort)	Hypothesis Testing High School Database	Hypothesis Testing High School Database	Hypothesis Testing High School Quiz
Week 5	Hypothesis Testing World Database	Hypothesis Testing World Database	Hypothesis Testing World Database	Hypothesis Testing World Quiz
Week 6	Hypothesis Testing Movie Database	Hypothesis Testing Movie Database	Hypothesis Testing Movie Database	Hypothesis Testing Movie Quiz
Week 7	Building a Datafile	Building a Datafile	Building a Datafile	Building a Datafile
Week 8	Creating a Datafile	Creating a Datafile	Creating a Datafile	Creating a Datafile
Week 9	Creating a Datafile	Creating a Datafile	Creating a Datafile	Creating a Datafile
Week 10				

Section 1 Introduction to databases

Five factors are important for the students to be successful when working with databases (Bezanilla, 1992). These are: general computing skills (Beek et al, 1989; Spavold, 1989; Underwood, Spavold, & Underwood, 1990), understanding the structure of the database (Spavold, 1989; Underwood, & Underwood, 1990), understanding the nature of the data (Shneiderman, 1978), understanding the use of Boolean logic (Spavold, 1989; Langhorne, 1989; Underwood & Underwood, 1990;

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[2] A full copy of the database including all lesson outlines and worksheets is found in Appendix 1.

Bezanilla & Ogborn, 1992), and familiarity with the content of the database (Hunter, 1983; Shneiderman, 1978; Underwood, Spavold & Underwood, 1990).

The first section of the database course is designed to give students experience in each of these five factors. It provides students with an introduction to databases and encourages students to become actively involved in the unit. During these initial lessons it is particularly important to expose students to the ways that data are structured. Not all students may be familiar with the way that data are organised and structured within a database and many students are not very successful at discovering the inherent organisation of information (Underwood & Underwood, 1987). Students need to become familiar with the way information is stored within fields within records in a database. Failure to recognise this structure may affect efficient data retrieval in future problem solving situations and students then may find databases difficult to use (Durding, Becker, & Gould, 1977; Shneiderman, 1978; Ray, 1985).

During this first section students are introduced to the terminology of database use and given experience in browsing data in the database, the layout of a database, arranging data within a database, sorting records in a database, and selecting records to work with from those contained in a database. Instruction is mostly effected through worksheets, teacher demonstrations, and hands-on computer work. Students need to become familiar with how each of these functions operate as the efficient use of these functions during data search has a big impact on the ease of use of a database program and the cognitive experiences of the child (Underwood & Underwood, 1990; Spavold, 1989).

Students need to know more than just which keys will activate which function. They need to know how to decide which is the most appropriate strategy to use in a given situation. To instruct students properly in this area there needs to be a separation of keyboard operations from problem solving operations (Stokes, 1994). Students not only need to know which key to press (procedural knowledge) but they need strategic problem solving knowledge. This leads to the second section of the course, that of hypothesis testing.

Section 2 Hypothesis Testing

Along with the mechanics of how to drive a database program, students need to be introduced to problem solving and metacognitive strategies as these strategies enable students to work properly with information within a database. Hypothesis testing activities are an effective way of promoting gains in strategic knowledge (Howe et al., 1992). These activities are considerably harder than simple information retrieval activities which are often emphasised in secondary schools (Underwood & Underwood, 1990). Hypothesis testing involves students in suggesting a relationship that may exist between two or more variables. They then work with the data to test to see if the relationship exists. This is not a trivial exercise. Riggs (1990) established a hierarchy of tasks for working with information contained in a database. He placed relating, that is, finding a relationship between two variables, above searching, ordering, and browsing. Similarly, Bezanilla (1992) placed tasks that require reasoning on the basis of data, such as finding a relationship between two characteristics, above tasks which require specification of simple retrieval statements, such as the retrieval of objects with a given characteristic or sorting objects on a characteristic. Clearly, hypothesis testing is one of the more demanding tasks students perform when working with information in a database.

In the present study, teachers were given instruction in the main teaching methods used in the course. The ability to engage students successfully in strategy training is very important. During database activities, students with search strategy training tend to solve their problems in shorter time periods than their counterparts (Ennis, 1993). Consequently, teachers can assist students by giving them many opportunities to practise database search strategies and to develop higher-order thinking skills so they may become good problem-solvers (Ennis, 1993).

A closer look at what students are expected to do during hypothesis testing reveals that students must postulate relationships, plan how to test relationships from the data, work with data to test relationships, and interpret the results of data manipulation to decide if the postulated relationship exists. Each of these facets of hypothesis testing was incorporated into the course. Consider each of these in turn.

Postulate relationships

One of the first activities that students have to do during hypothesis testing is to postulate the existence of relationships in the data. To help students do this effectively database courses should include direct attention to what makes a good question and what relationships may exist in the data (Senior, 1989: 158). Also, because of the need for students to be familiar with the content of the database and the categories that the data is stored within, hypothesis testing activities should include a concept formation discussion (briefing) of the database categories and the context in which the students are going to be working with the database. Whenever students are introduced to a new database, time should be spent briefing them about that database. Although many authors have stressed the importance of students being able to conduct their own investigations when working with databases, far less attention has been paid to the importance of students being aware of the problem they are trying to solve, or questions they need to ask to find appropriate answers (Bezanilla, 1992).

Plan how to test relationships from the data.

Students need good metacognitive skills to be successful during hypothesis testing. Research concerning effective learning, in both adults and children, highlights the importance of these skills (Baird, 1992). Metacognition enables students to plan, monitor, and evaluate, and these skills will help students formulate search strategies to test their hypothesis and deal with the results of the searches.

In particular, planning, one of the first stages in metacognition, is very important. The selection of strategies and the quality of query information is the key to effective problem solving using databases. Students need to plan how they can ask worthwhile questions and how to translate their questions into actual search strategies that they can deploy using the database software. To do this they need to take time to consider the different search possibilities. Many students do not always use the computer to its full advantage. There is a tendency to use the computer to do part of the work, leaving some work for the student to do (Bezanilla, 1992). As students plan their search strategies they need to learn to rely less heavily on the browse function and more heavily on sort and select functions. In doing this they will be using the computer to perform more of the information processing task.

Work with data to test relationship

After planning how they are going to test a proposed relationship, students need to implement their respective strategies. They draw on the experience that they have gained from the first part of the course and use the various database commands to sort, select, and browse through the data. There is usually no right and wrong way to manipulate the data, however, some commands are much more efficient than others and provide a more direct path to a meaningful arrangement of the data. During this phase of their work, students need to monitor their progress continually to make sure that they are progressing according to their plan.

Interpret the results of data manipulation to decide if the postulated relationship exists.

After manipulating the data, the next stage is often the most difficult for students. They need to interpret the results of their search. Students should not only be taught about the use of a database but also be given significant guidance in how to interpret results (Welford, 1989; Langhorne, 1989) as students need this guidance to enable them to reach conclusions about their work.

One particular technique that may be used is the method of thirds. The students look at the top one third of the data set and then they look at the bottom one third. They compare the two to see if there is a significant difference and/or progression. Students also need practice in looking for trends in the data set. They need to be able to determine if there is a relationship between two different variables in two separate columns. For example, as the numbers in one column get bigger, do they also get bigger in the second column or do they get smaller? What sort of relationship therefore exists? Most students find this phase of hypothesis testing reasonably difficult and the method of thirds may help them with this difficulty.

Section 3 Building a data file

The third main section of the course involves students in building their own datafile. Building data files gives students the chance to apply many of the information processing skills they have learned in the first two sections of the course to different curriculum areas. Building a datafile requires students to add information to a database file in which the structure (fields) have already been established by a third party. Once students have built a database they can then test their hypotheses about the data in the same way they did in part two of the course.

These activities are more successful if students have a purpose for classifying and working with data. Researchers have identified that there are links between information seeking goals and the collection and organisation of data (Underwood & Underwood, 1990). One way of accomplishing this is through the use of authentic tasks. These may provide opportunities for computing teachers to team up with teachers from other discipline areas to help their students to work on authentic tasks using computer technologies. In the present course, although students were working within the Computing Studies syllabus, the databases they built and worked with contained authentic data. In this way it was hoped that some of the benefits associated with the use of authentic data would be realised.

Section 4 Creating a data file

The last section of the database course involves students in creating a datafile. During this activity students establish the structure of a database file and then collect the data to enter into it. The creation of a database provides a good environment for the selection and organisation of data and as students create a database they use information handling skills that include deciding on field headings, classifying and coding, and data entry.

Students are more focused in their work if they have a purpose for creating a database. If this is not clear the whole activity may prove to be disappointing (Underwood et al., 1990: 77; Bezanilla, 1992). Also, particular attention needs to be paid to the collection and organisation of the data in the database as the initial organisation of the system often determines the later usefulness of the file (Underwood et al., 1990).

As students create their database file they are involved in the coding of data. There is evidence that this task is not always easy (Spavold, 1989) and boredom during the data entry stage can be a real problem (Hodson, 1989; Blease & Cohen, 1990). Data entry can be a long process and of doubtful educational value so teachers may have to think of creative ways to deal with this problem. One solution may be to have students work on data entry at home and in doing so relieve some of the time pressure from the classroom. Also, the teacher may engage some help from parents, secretaries, or other parties, for data entry outside the classroom.

Once data entry has been completed students would then form and test hypotheses in the same way as they have in the previous sections. Students conclude the final section of the database course by writing a report on their findings. Generally it is expected that the level of motivation will be high as students working on this last section of the course will be working on a topic that they have selected themselves.

Teaching Methods

As discussed in Chapter 4 there are a number of different teaching methods that may be used to optimise the learning environment during database activities in the classroom. Those that were used in this course specifically to encourage students to work with data and develop metacognitive skills include direct instruction of strategies, modelling, scaffolding, reflection and cooperative learning. Teachers were encouraged to use each of these teaching methods wherever it was possible and practical. Consider each in turn.

Direct Instruction

Using this strategy teachers give students direct instructions as to what strategies they should use in various situations. When using direct instruction there is a need to be careful that the context of the strategy selection is made clear. It is more productive to use direct instruction within the context of a particular problem than in a general context as students may have difficulty applying general guidelines to specific situations.

Teachers should be encouraged to take the time to engage in direct instruction of strategies. In secondary classrooms the prevailing instructional focus is on content coverage (Scanlon et al., 1996). For example, Scanlon, Schumaker and Deshler (1994) reported that secondary teachers were only willing to spend 10 per cent of a class session on the direct instruction of strategies. Due to the importance of both procedural and strategic knowledge to database activities, teachers were encouraged to engage in direct instruction of strategies throughout the database course.

Modelling

Teachers need to make the strategies that they are using clear to students so that they have a chance of copying them and implementing similar strategies during their own problem solving. Modelling, with explanation of strategy use, is an effective way of enhancing student learning (Volet, 1991). To model strategies effectively, teachers need to think aloud during demonstration classes so that students have an opportunity to witness strategy use that may normally be covert. Particularly during modelling of expert performance (including cognitive processes), it is important that there is integration of both demonstration and explanation during instruction (Collins, 1991). Learners need access to explanations as they observe details of the modelled performance. Students may then develop 'conditionalised' knowledge, that is, knowledge about when and where knowledge should be used to solve a variety of problems (Wilson & Cole, 1992).

Scaffolding

Students often need guidance when they commence problem solving activities. One way to give them this, and to encourage them to be more metacognitively aware, is to provide them with a structure in the form of a scaffold to support their learning (Ehman et al., 1992). Researchers have found that this technique increases performance on problem solving tasks and increases metacognitive awareness (King, 1991; Stokes, 1994). During the database course students were encouraged to DEAL with their problems. This is a heuristic that was adapted from the work of Bransford and Stein (1984). The way to DEAL with problems is to:

1. Define the problem.
2. Explore alternative approaches.
3. Act on a plan.
4. Look at the effects.

This heuristic was incorporated throughout lessons and became an integral part of worksheets.

Reflection (debriefing)

One important aspect of the DEAL heuristic is the use of time near the end of the problem solving exercise to look at the effects of the activity. The use of reflection may help students as it allows them to negotiate meaning and argue their ideas, and is particularly useful in a whole-class forum (Maor, 1993). Teachers need to assign off–computer time so that students have time to reflect on what they have done with the computer as well as having the opportunities to discuss with their peers the processes involved in solving problems.

Cooperative Learning

Throughout the database course students were encouraged to work in teams. This approach was at times adopted out of necessity because there was not enough computers in the room for each student to have a single computer. For whatever reason, such a practice does have support at the theoretical level[3]. Vygotsky (1978) argues that all higher psychological functions have social origins. More capable peers should be encouraged to assist the less capable ones and students should be encouraged to talk about their problem solving activities within their group (Ehman, et al., 1992; Healy et al., 1995). An important implication of Vygotsky's argument is the need for an increase in interaction between the teacher and the learner, as well as between learners.

Teaching the Course

There are many factors that could influence the successful implementation of the database course. These include time constraints, prior student knowledge, the use of cooperative student groups, and the use of structure by the teacher during the problem-solving process (Ehman, et al. ,1992). The successful use of computerised databases in the classroom is also linked to the nature of teachers' epistemologies (Maor & Taylor, 1995). Pedagogies that place a major emphasis on the rote learning of information are the hallmarks of teachers who conceive of learning as the absorption and reproduction of proven knowledge. In contrast, a constructivist-oriented pedagogy places a major emphasis on engaging students individually and socially in problem-posing and problem solving activities. A constructivist pedagogy engages students in asking creative questions, reflecting on their learning, debating wrong answers, clarifying confusion, considering new ideas, testing their conflicting ideas, and negotiating meaning in group discussions (Bell, 1991). An emphasis was given to the constructivist approach during this course by encouraging students to engage in many of these activities.

It is important that teachers have some experience with databases before the commencement of the database course. While children develop a conceptualisation of a database system from experience with it, rather than needing to conceptualise prior to experience, teachers need a firm prior conceptualisation of the system in order to assist

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[3] See the discussion on cooperative learning in Chapter 3.

the children. Successful conceptualisation, like experience in building the database, has been shown to aid the formulation of good efficient queries (Spavold, 1989).

Teachers also need to recognise the dynamic nature of the learning process and be metacognitively aware in their teaching (Biggs & Moore, 1993). Metacognition involves planning, monitoring, and evaluation and teachers should participate fully in all three activities. As teachers plan for database activities, they select appropriate data that fits within the curriculum. They choose instructional approaches that will enhance both cognitive and social skills and they set goals for individuals and groups within the class. Good planning also involves teachers in deciding how to evaluate the outcomes of learning.

Once the learning process commences teachers are actively involved as they monitor and interact with students in the learning environment. Teachers act as managers of the activities, organising rooms and equipment, making sure that students have suitable access to computers. They act as facilitators of the subject matter, and as they are familiar with both the subject matter and database operations, they can provide support, encourage, observe, and reinforce appropriate behaviours. Teachers also act as guides in the subject matter and learning activities. They encourage learners to explore the data and ask questions of the database. They help students in their analysis of data and conclusions that they draw. Teachers also act as participators in the learning process. They model strategies, listen to ideas, take notice of student activities and are interested in their discoveries.

As they interact and monitor student activity, teachers need to adjust the database activities continually to maximise student involvement and enhance the learning process. Teachers often only become aware of some of the student presage factors that affect the learning process as they monitor student performance once the database activities have commenced. They may have to move quickly to refine the instructional process to compensate for these factors by including variation of activities, adjusting activities to match students' pace of performance, reorganising the room to encourage cooperative working groups, and monitoring technical aspects of the database activities. Teachers may also have to refine the database activities so that they better encourage students to adopt deep and achieving approaches to their work. This may mean the removal of extrinsic motivational devices and the encouragement of student curiosity in the data. The database course was structured so that teachers had the time and room to perform many of the above teaching activities. Also, an ongoing interaction between the principal researcher and teachers encouraged them to perform these tasks.

The Development of the Instruments

The second stage of the present study entailed the development of the testing instruments. This took place during the pilot study conducted in term 4 of 1993. The pilot study was also used to trial the database course used as the intervention in the main study.

Sample

A two-stage stratified sample of students in year nine from the Hunter region was used in the pilot study. The two stages consist of schools and classes. All students from each of the classes selected participated in the study. The sample consisted of 278 students in nine classes from six schools in the Hunter region. The size of the sample was determined so that the ratio of sample size to variables in analyses was no smaller than 10:1 to enable group statistics to be used (Bourke, 1984). Not all variables that were included in the main study were included in the pilot. Only those that needed further development or validation were used.

Development of Instruments[4]

A number of instruments were developed during the pilot study. These included measures of:

- Information Processing Ability
- Flexibility in Learning
- Knowledge Measures
- Classroom Practices
- other variables

The background of each of these instruments will now be discussed in turn.

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[4] A copy of the instruments used in the main study is found in Appendix 2.

Information Processing Ability

An Information Processing scale was developed by White (1985) during a study on computer-based file management programs and information processing. The 16 item instrument was designed to measure students' ability to:

- recognise when they have been given sufficient information to solve a given problem.
- recognise when sufficient information has been provided to solve a given problem.
- discriminate between efficient and inefficient organisation of information to solve a given problem.

During White's study, the instrument failed to load on three independent factors so all the items were used as a single scale. The reliability of this scale was found to be 0.66. This instrument formed the basis of the information processing ability measure. Two scales developed by the researcher were added to White's scales for the present study. The first contained six items designed to measure how well students could form a hypothesis from available data. The second scale contained six items designed to test how well students could interpret the results of searching and other data manipulation when working with databases. The final form of the Information Processing Ability instrument used in the pilot study, therefore, contained five scales and a total of 28 items.

Flexibility in Learning

The Student Flexibility Questionnaire (SFQ) is a 21 item instrument that was developed by Cantwell (1994) to determine students' flexibility in their learning. Within the area of executive strategy control he identified two positive attributes (planning and monitoring) and two negative attributes (inflexibility and irresoluteness). Empirical studies conducted at the tertiary level, first with Education students and then with Nursing students, validated the instrument with the planning and monitoring attributes generalising into a single adaptive strategy control dimension, while the inflexibility (algorithmic strategy control) and irresolute dimensions remained as separate negatives. All of the three final factors had a reliability greater than 0.8.

The SFQ had not been previously used with secondary students. During the pilot study the items were reviewed and some items were reworded in an attempt to ensure appropriateness for year nine students.

Knowledge Measures

Pre- and post-knowledge tests were used in the Pilot study. The pre-test was to control for prior knowledge and the post-test was used to determine knowledge levels at the conclusion of the course. Given that it is desirable to not only test for recall of detail, but also to test for levels of abstraction of knowledge (Kirby, 1991), the Knowledge instrument contains multiple choice items that test for detail, main ideas, and themes of the content areas covered within the database course. There was one scale developed for each of the databases used in the course. The three knowledge scales used were the High School scale which contained nine items, the World scale which contained fourteen items, and the Movie scale which contained nine items.

Classroom Observation Instrument

The classroom is a place where a large amount of complex activity occurs at any one time. Because of the widespread call for ecologically valid research, the classroom is the most appropriate place to observe the learner during instruction (Mayer, 1996). The researcher, however, is faced with a dilemma as to the best way to access and record this activity. In solving this dilemma, the researcher has to make decisions that usually involve making value judgements involving methodology and instrumentation (Smith, 1996).

One way to record observations about the learning environment, methods of instruction, and learner activity, is through structured classroom observations. Proponents of this technique claim that many benefits result from performing observations in the classroom setting that focus on educational processes (Croll, 1986). Opponents of structured observation systems argue that the focus of such instruments is on predetermined criteria reflecting implicit models of teaching. Another criticism of structured observations is the loss of the individuality of the student and the inability of observers to be involved in shared understandings (Smith, 1996).

As the classroom is a rich and diverse source of activities, observations will not be able to cover the complete range of all classroom activity. However, if structured observations are focused on the activities of interest, the detail that is recorded will be most relevant to the study (McIntyre & Macleod, 1993). It is important that classroom observations are focused on the study purpose. To this end, a purpose-built observational scheme was designed so that classroom observations could specifically target the classroom measures that were considered important to the present study.

Development of the Classroom Observation Instrument

The inclusion of measures of teaching and learning processes in the study required gathering data from the classrooms on aspects of classroom context, teaching processes, and student behaviour. The choice of which data to collect is important to the success of any study of classroom teaching and learning practices (Anderson & Burns, 1989). The Classroom Observation Instrument developed for use in the current study was used to record classroom context measures throughout the database course. The instrument focused on the teaching processes employed in the classroom and the classroom activity of the students. It was also concerned with how effectively the teachers were implementing the database course described earlier in this chapter.

Each classroom was observed for five separate lessons with the primary researcher conducting all of the lesson observations. The overall approach to observing and recording classroom activities was to break down a lesson into two-minute blocks. As the lesson progressed, the observer would record which activity was occurring during that time. This gave the observer an indication of approximately how much time per lesson was spent on each of the activities of interest. At the end of the lesson the observer would then rate each of the teaching activities on a five-point Likert scale as to their importance to the lesson. A five-point Likert scale was also used to summarise the frequency of the classroom activities and to record a rating for the overall implementation of that particular lesson in the database course.

The instrument itself was divided into four sections: background information, teaching processes, classroom activity, and implementation. Consider each in turn:

Background information on the lesson was coded at the beginning of each lesson at the top of the form. Details of school, class, teacher, date, and lesson number were recorded.

Teaching processes recorded by the observer included those teaching strategies considered important during the database course. They included:

- *Concept formation* includes time taken by the teacher to orientate students to the database activities to be undertaken during that lesson. It usually included a discussion on the topic and the information included in the database.

- *Directing* is a procedural strategy used by teachers to indicate to students what they should be doing during the lesson.

- *Instruction of strategies* is a method where teachers give direct instruction on strategy use. This usually entailed teachers verbally communicating procedural and strategic knowledge to the students.

- *Scaffolding* is a method were teachers support the students information processing endeavours by providing a structure for them to work within. During the present study approximately half of the students worked using the DEAL heuristic as a scaffold.

- *Modelling of strategies* requires teachers to demonstrate various strategies to students. Successful modelling requires teachers to verbalise declarative, procedural, and strategic knowledge used during the demonstration so that students are exposed to knowledge which may normally be covert during problem solving.

- *Debriefing* is a strategy in which teachers engage the class in reflection by discussing their findings from the database activities. During these discussions students have an opportunity to share their knowledge and discoveries, and debate with their peers findings that may conflict. It is a very important time of peer interaction.

Classroom activities recorded by the observer were measures of how students and teachers were interacting with the database course materials. They included measures of:

- *Use of worksheets* by the teachers and students during the course. This observation provided the researcher with an indication of how teachers and students were using the course materials.

- *Working as a group* Peer interaction was considered a very important factor in the establishment of a rich cognitive environment in the classroom. This observation measure was designed to indicate how successfully the students in any classroom were involved in peer interaction and working as a group.

- *Working with the DEAL heuristic* The students in the study were asked to work with the DEAL heuristic. This observation indicated how successful the students were in working with this cognitive aid.

- *Students on Task* was a measure of how much of the lesson that students remained working on the database activities.

- *Teacher Engagement* was a measure of the level at which the teachers interacted with the students during the database activities.

Implementation recorded how successful the various teachers were in implementing the database course in their classrooms. It was not designed to be a measure of how well the students worked within the database course, but rather, an overall measure of how successful the teachers were in presenting, and involving the students, in the database activities.

Other Variables

Apart from the student responses to the scales mentioned above, background information on students and classrooms was collected. This included information on the student's gender and age, and the type of hardware, and software used in the classroom.

The Pilot Course

Term 4 is traditionally interrupted with exams and end of year activities. Because of this the pilot study was truncated to seven weeks. The course followed closely the one developed during the preliminary study with the omission of section four. The students worked through the first three main sections of the preliminary course. Section 1 involved the students in exercises that introduced them to databases and taught them how to manipulate data contained in a database. Section 2 introduced students to problem solving and hypothesis testing using databases. Section 3 provided students with a database shell and they built a database file and performed hypothesis testing. During the pilot study several periods were also taken up with the administration of various testing instruments[5].

Analysis and Results

The data collected from students involved in the pilot study were analysed using principal components factor analysis and alpha reliability testing (SPSS Inc., 1993) as the sample was too small for confirmatory factor analysis using LISREL8. T-tests were used to establish that there were no significant differences between the schools on the outcome measures (Information Processing, Knowledge, and Student Flexibility in Learning) and that they could be included as a single unit in the analysis. During the factor analysis items were discarded if they failed to load on the appropriate factor for which they were designed, or if they loaded on more than one factor. The factor loadings for the items retained in each of the scales used in the pilot study are shown in Appendix 6.

A summary of results for each of the scales follows and is shown in Table 6.2.

Information Processing Scale

Factor analysis indicated a single factor with an eigenvalue greater than one. The factor contained 23 items and the alpha reliability for the scale was found to be 0.84 (n=198).

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[5] A Table showing the make up of the pilot course is found in Appendix 6.

Table 6.2 Summary Statistics for Pilot Study Final Scales

Scale	No. of Items	Reliability
Information Processing	23	0.84
Knowledge	14	0.69
SFQ adaptive	07	0.82
SFQ maladaptive	13	0.79

Knowledge Scale

Factor analysis indicated a single factor with an eigenvalue greater than one. The factor contained 14 items and the alpha reliability for the scale was found to be 0.69 (n=167).

Student Flexibility Questionnaire

Factor analysis indicated two factors with an eigenvalue greater than one. The first factor contained 7 items and the alpha reliability was found to be 0.82 (n=152) while the second factor contained 13 items and the alpha reliability was found to be 0.79 (n=152).

The Main Study

The main study was conducted during term 3 of the 1994 school year. The schools were randomly split into two groups using a lottery method with the two groups working with a database course that was slightly different. The first group worked with the database course that made use of the DEAL heuristic as a teaching method while the second group did not have the heuristic included as a teaching method. Apart from this difference, the courses given to the two groups of schools were similar in all other aspects.

Sample

A two-stage stratified sample of students in year nine from the Hunter region was used in the main study. Schools were selected first, then classes, and all students from each class selected participated in the study. The sample consisted of 541 students in 25 classes from 12 schools in the Hunter Region as shown in Table 6.3.

Table 6.3 Main Study Sample

Level- 4 Units:	**12**	**Schools**				
Level- 3 Units:	**18**	**Teachers**				
Level -2 Units:	**25**	**Classes**				
Level -1 Units:	**541**	**Students**				
School no.	10	11	12	13	14	15
Teachers	1	1	1	2	1	1
Classes	1	1	1	2	3	2
Students	20	22	27	56	48	44
School no.	16	17	18	19	20	21
Teachers	1	2	2	3	2	1
Classes	2	3	2	4	2	2
Students	50	56	45	85	42	46

The Course

The intervention courses used in the main study were developed from the one used in the preliminary study and refined in the pilot study. A full copy of the course, including lesson plans and worksheets, is found in Appendix 1.

As in the preliminary and pilot courses, the course commenced by introducing students to the concept of a database and giving them experience in performing operations such as browsing, sorting, selecting information. Students were then asked to work with three databases which gave them experience in hypothesis formation and testing. Finally, students gained experience entering information they had collected into a database. This led into a research project in which students collected information, created a database file, and tested various hypotheses (this final section was omitted from the pilot course). For a more detailed discussion of the course see the section on the development of the course earlier in this chapter.

Throughout the course, the students also completed various instruments. A timetable showing the various lessons and instruments (used by both groups) during the main study is included below in Table 6.4.

Table 6.4 Main Study Database Course Schedule

Week 1	Introduction Lesson and Testing Instrument 1	Introduction to Databases	Testing Instrument 2	Database Terminology
Week 2	Browsing /Layout /Arranging	Browsing /Layout /Arranging	Testing Instrument 3	Arranging / Sorting
Week 3	Testing Instrument 4	Selecting Records (find)	Selecting Records (find)	Selecting Records (find/sort)
Week 4	Selecting Records (find/sort)	Hypothesis Testing High School Database	Hypothesis Testing High School Database	Hypothesis Testing High School Quiz
Week 5	Hypothesis Testing World Database	Hypothesis Testing World Database	Hypothesis Testing World Database	Hypothesis Testing World Quiz
Week 6	Hypothesis Testing Movie Database	Hypothesis Testing Movie Database	Hypothesis Testing Movie Database	Hypothesis Testing Movie Quiz
Week 7	Building a Datafile	Building a Datafile	Building a Datafile	Building a Datafile
Week 8	Creating a Datafile	Creating a Datafile	Creating a Datafile	Creating a Datafile
Week 9	Creating a Datafile	Creating a Datafile	Creating a Datafile	Creating a Datafile
Week 10	Creating a Datafile	Testing Instrument 6	Testing Instrument 7	Testing Instrument 8

Main Study Instruments

Data were collected for the main study using a number of different tests, questionnaires, and surveys. These were combined into eight instruments as shown in Table 6.5 so that any one instrument would not be too taxing on the students, and each of the instruments could be administered during a single 40 minute class period. Copies of the scales used in these instruments are found in Appendix 2.

Table 6.5 Main Study Instruments [6]

No.	Items & Scales	Origin	No. Items	No. Scales
1	Name		1	-
	School	Beamish 1994	1	-
	Age	Beamish 1994	1	-
	Gender	Beamish 1994	1	-
	Computer Experience	Beamish 1994	9	1
	Information Processing 1	Beamish 1994	13	2
2	Information Processing 2	Beamish 1994	19	3
	Personality	Beamish 1988	12	1
3	Knowledge	Beamish 1994	32	3
4	LPQ	Biggs 1987	36	6
	SFQ	Cantwell & Beamish 1994	21	3
5	Knowledge	Beamish 1994	32	3
6	Database Processing	Beamish 1994	21	1
7	Information Processing 2	Beamish 1994	19	3
8	Information Processing 1	Beamish 1994	13	2
	Attitude to Computers	Beamish 1988	14	1

Background to the Testing Instruments

Some of the testing instruments contained scales that had been developed by researchers conducting research prior to this study while others were newly-developed scales. The existing scales were:

[6] A full copy of the scales used in the main study is found in Appendix 2.

Personality

A 12 item scale on personality was included in the study. This scale is adapted from the measure of extroversion/introversion developed from the Eysenck Personality Inventory (Eysenck & Eysenck, 1964). The scale has a potential range from 0, indicating an introvert personality, through to 1, indicating an extroverted personality. In a previous study in N.S.W. schools, the alpha reliability of the scale was found to be 0.69 (Beamish, 1988).

Approach to Learning

Biggs (1987) developed the Study Process Questionnaire (SPQ) for use with tertiary students and the Learning Process Questionnaire (LPQ) for use with secondary students in assessing their preferred approach to learning. Biggs identified that students adopt either a surface, deep, or achieving approach to their learning. As described in Chapter 4, a surface approach is adopted when students are motivated by factors extrinsic to the learning task, a deep approach is adopted if students are motivated by factors intrinsic to the learning task, and an achieving approach reflects a students desire to obtain high grades. Each approach has a motive scale and strategy scale, and as a consequence, the LPQ contains six scales made up of six items each.

A series of studies has confirmed a three factor solution for the approach items (Watkins & Hattie, 1990; Kember & Gow, 1991; Watkins, Regmi & Astilla, 1991; Cantwell & Millard, 1994; Murray-Harvey, 1994) with Cronbach alpha for the six subscales ranging from 0.51 (Surface Motive) to 0.77 (Achieving Strategy). Using LISREL generalised least squares analyses Biggs (1994) found that all scales had goodness of fit estimates higher that 0.97, however, the root mean square residuals were higher than the accepted level of 0.05.

Student Attitudes to Computers

Beamish (1988) trialed an instrument developed by Loyd and Loyd (1985) to measure student attitudes to computers. Principal components factor analysis gave a two factor solution. The first factor (computer liking) contained 8 items with an alpha reliability of 0.89. The second factor (computer confidence) contained 6 items with an alpha reliability of 0.76.

Instruments Developed during the Pilot Study

As well as the scales developed by researchers in previous research, a number of the scales used in the main study were developed during the pilot study. These were:

- Information Processing scales
- Student Knowledge scales
- Flexibility in Learning scales
- Classroom Observation measures

For further details of these instruments see the section on the Pilot Study earlier in this chapter.

The Content and Distribution of Instruments

The various scales developed during previous research and newly developed scales from the Pilot Study were combined to form the various testing instruments. Details of the combination of the various tests, questionnaires, and surveys included in the testing instruments follows.

Instrument 1 contained items to collect data on age, gender, previous computer experience, and pre-test information processing ability. Age (recorded in months) and gender (0=female, 1=male) consisted of a single item each. A total of 18 items were used to collect data on students' previous computer experience and these items covered frequency of use, and type of computer use at home, school (both in and out of class), and at other places. Also information was collected on students' previous use of database software packages. Instrument 1 also contained the Information Processing 1 pre-test. A total of 13 multiple choice questions were used to collect data on the pre-test Hypothesis Formation scale (six items) and the pre-test Interpretation scale (seven items).

Instrument 2 contained a total of 32 items. The first 13 of these made up the Personality scale (Beamish, 1988). This scale used a two-point response scale (yes or no) and was used to measure extroversion/introversion. The second part of Instrument 2 contained the Information Processing 2 pre-test. This test was made up of 19 multiple choice items and was used to collect data on the pre-test Organisation scale (seven items), pre-test Sufficient Information scale (seven items), and the pre-test Relevant Information scale (five items).

Instrument 3 contained the three pre-test knowledge scales. Each of these scales used multiple choice items. The first scale contained nine items and was used to assess students' pre-test High School Knowledge. The second scale contained 14 items and was used to assess students' pre-test World Knowledge and finally the third scale contained 9 items and was used to assess students' pre-test Movie Knowledge.

Instrument 4 contained the Learning Process Questionnaire (36 items) and the Student Flexibility Questionnaire (21 items). Both of these instruments used a five-point Likert response scale.

Instrument 5 was administered in three stages. It contained the three post-test knowledge measures. Each scale was administered at conclusion of work on the database that the test covered. These instruments contain the same multiple choice items as the pre-test measures. The first scale (nine items) and was used to assess students' post-test High School Knowledge. The second scale (14 items) assessed students' post-test World Knowledge and finally the third scale (nine items), assessed students' post-test Movie Knowledge.

Instrument 6 contained the Information Processing 2 post-test. This test was made up of 19 multiple choice items and was used to collect data on the post-test Organisation scale (seven items), post-test Sufficient Information scale (seven items), and the post-test Relevant Information scale (five items).

Instrument 7 was used to collect data on students' knowledge of databases. This instrument was made up of two parts. Part A consisted of 15 multiple choice questions that were answered without the help of a computer covering aspects of students' knowledge about databases. Part B was made up of six open ended questions about information that could be found using the 'Fish' database. The students were required to use the database on the computer to obtain answers to these six questions.

Instrument 8 was made up of two sections and was the last that the students were asked to complete. The first section contained the Attitude to Computers questionnaire which was made up of two sub-scales, computer confidence (six items), and computer liking (six items). This questionnaire made use of a four-point Likert response scale. The second section contained the Information Processing 1 post-test. A total of 13 multiple choice questions were used to collect data on the post-test Hypothesis Formation scale (six items) and the post-test Interpretation scale (seven items).

Analytical Framework and Analysis

Introduction

The aim of the present study was to examine how effectively students could use database management packages to manage and work with information in the classroom. The study sought to detail specific aspects of classroom life through the use of questionnaires and observations to more fully understand the complex interplay of factors that contribute to the dynamic learning environment in the classroom. Because of the large number of factors that have the potential to influence learning in the classroom, it is important for research studies to focus on the variables of interest even though this is reductionist in form (Croll, 1986). No research study can hope to adequately cover all variables that may contribute to learning in the classroom, so choices need to be made about what to include and what to overlook. These choices should be made based on theory and prior research, and in the current study led to the establishment of the General Model for Analysis (see Chapter 5). The study then proceeded to test the goodness-of-fit of the General Model for Analysis to the data.

An Overview of Multilevel Techniques

Data collected from studies of educational practice often have a nested structure due to the different levels of structure found within the school systems. Students are grouped in classes and these classes are grouped within schools giving a three level structure. At times, schools can be grouped within regions, regions within states, and states within countries, and so the levels increase. The present study, however, is concerned with the three level structure of students, classes, and schools.

Variables included in the study can be correlated with others at the same level as well as others at different levels. Analysing these complex associations requires an approach that can accommodate these complex patterns. Smith (1996: 108-132) outlines an analytical approach that involves the development of theory-based networks of association linking variables of interest. The patterns of association are expressed in the form of path diagrams which are analysed using structural equation modelling techniques as heuristic devices to identify and decompose the patterns of association. Structured equation modelling provides a means of translating theoretical relationships into mathematical expressions that can be used to estimate associations between the variables (Bourke, 1984: 30; Keeves, 1988: 724; Williams, 1988; Smith, 1996: 110).

Following this approach, the hypothesised pattern between the variables has been presented in the form of a General Model for Analysis (developed in Chapter 5), with specific research questions reflected in the various sub-models. The use of a causal model in the present study was considered appropriate as it provides a foundation for an analysis in which variation in dependent variables is described in terms of contributions from a range of independent variables (Pedhazur, 1982; Tatsuoka, 1988; Smith, 1996).

The establishment of a causal model, with its network of hypothesised relationships needs to be based firmly in theory (Smith, 1996). The aim of the analysis is then to determine if the causal model is consistent with the data (Pedhazur, 1982). Rowe and Rowe (1992) sound a note of caution in outlining that causation can not be proven through statistical modelling, and they suggested that relationships established under such conditions be viewed as being influenced rather than being caused. The introduction of multilevel analysis has helped the analysis of statistical models to reflect causal reality more accurately due to the better representation of ecological validity that is possible. However, the specifying of causal models remains a process of synthesising theoretical considerations throughout the analysis.

After Smith (1996), a two-stage analysis was used in this study that incorporated both LISREL8 (Joreskog & Sorbom, 1993a) measurement models and multilevel analysis using MLn (Rasbash & Woodhouse, 1995). The first stage involved using LISREL8 in the development of one-factor congeneric measurement models to provide optimally weighted composites from multiple indicators of latent constructs. Scale scores were developed in this way. The use of LISREL8 and its preprocessor PRELIS was considered desirable due to the way that these packages treat the mixture of ordinal and mixed scale types found in this study (Rowe & Rowe, 1992). Pearson product-moment correlations should only be used where both variables are measured on continuous scales as they are known to be biased downward when used with ordinal and mixed scale types. LISREL8, in computing bivariate relationships between ordinal and mixed scale types, gives appropriate recognition to these scales through the use of polychoric correlations for relationships between pairs of ordinal variables and polyserial correlations for relationships between ordinal and continuous variables. PRELIS2 (Joreskog & Sorbom, 1993c) calculates tetrachoric correlations, applicable to relationships between pairs of dichotomous variables, as a subcategory of polychoric case, and biserial correlations, applicable to relationships between mixed dichotomous and continuous variables, as a subcategory of the polyserial case.

The measurement models were used in stage two of the analysis where the composites formed in stage one were passed to MLn multilevel analyses to establish the significance of multilevel effects. Rowe (1992) has outlined a strong case for the use of advanced statistical techniques and describes the serious limitations of studies that fail to do so.

Preliminary Analyses

Before commencing the two-stage analysis outlined on the previous page, the current study first made use of univariate analyses to screen the data. This was accomplished using SPSS (SPSS Inc., 1993). Single-level bivariate relationships were then computed to establish likely patterns of association. The preliminary bivariate analysis was restricted to the examination of relationships between variables measured at the same level. This background information was used as a guide to indicate which variables were suitable for forming into composites in the event of a need to simplify the model subsequently for analysis. Also, those variables that had a significant bivariate relationship with an outcome variable were noted as an indication that these variables were more likely to contribute effects in terms of hypothesised causal models.

Development of Factor Structures

In classroom research, many areas of interest cannot be directly observed and such variables are measured indirectly through the use of indicator variables (Joreskog & Sorbom, 1993b: 23; Holmes-Smith & Rowe, 1994: 5). Also, developing constructs often leads to a more parsimonious treatment of the data and helps reduce problems associated with multi-collinearity. Holmes-Smith & Rowe (1994) advocated the use of one-factor congeneric models as a way of developing optimally weighted composite variables from indicator variables under conditions of restricted sample size. One-factor congeneric models may be developed using LISREL8. Generally, these measurement models specify and estimate the contribution that latent variables make towards the performance of a number of observed indicators (Williams, 1988: 772; Joreskog & Sorbom, 1993a: 114; Holmes-Smith & Rowe, 1994: 5).

Using one-factor congeneric models improves the reliability and validity of the composite constructs (Holmes-Smith & Rowe, 1994: 4). However, LISREL8 suffers from the problem of many general linear model based programs in that it cannot provide accurate estimates for non-random and clustered samples. Consequently, LISREL8 was used in the current study to develop one factor congeneric measurement models of latent constructs (Joreskog & Sorbom, 1989; Holmes-Smith & Rowe, 1994)[7]. These variables are then used in multilevel structural equation models.

When developing one factor congeneric models there is a sample size requirement. PRELIS2, the pre-processor to LISREL8, requires a minimum number of cases to produce the asymptotic covariance matrices necessary to compute parameter estimates and fit statistics. Where there are fewer than 12 indicator variables, a minimum of 200 cases is required. Twelve or more indicator variables require $1.5k(k+1)$ cases, where k is the number of indicator variables (Holmes-Smith & Rowe, 1994: 4)[8].

The Multilevel Analyses

Within most schools in Australia, students are taught in classes, and classes are grouped in schools. Class membership influences student attitudes and achievement, while schools influence both teacher and student behaviours and attitudes. Because data gathered to analyse classroom learning are multilevel, educational research into teaching and learning has struggled with 'unit of analysis problems' (Rowe, 1992; Goldstein, 1995). If students become the unit of analysis, then teacher, class, and

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[7] The scales used in the current study were developed initially using confirmatory principal components techniques (Ainley & Bourke, 1992). It is the development of the final form of the scales being described here.

[8] Although the work carried out by Holmes-Smith and Rowe (1994) was based on single-level designs their work was used as a guide in the current multi-level study.

school data are disaggregated to the student level. If class, teacher, or school become the unit of analysis then student data are aggregated to the higher level, or in the last case, student, teacher, and class data are aggregated under school (Smith, 1996: 116).

Multilevel analysis programs such as MLn (Rasbash & Woodhouse, 1995) provide solutions to the analysis of hierarchically structured data. Through simultaneous estimation of variables measured at different levels of the hierarchy, multilevel analysis avoids aggregation bias related to choice of unit and level of analysis problems. Also, multilevel models avoid analytical problems arising from data clustering such as level of analysis problems, heterogeneity of regression, and related problems of model mis-specification due to violations of the assumption of independence between measures taken at different levels (Smith, 1996: 114).

In the current study, the specialised multilevel program MLn (Rasbash & Woodhouse, 1995) was used to develop two-level multilevel models. The model detailed here applied to level-1 student variables, and level-2 classroom variables. The school level was not implemented due to the complex nature of the hierarchy in the sample. Differences between schools were detected by including school as a dummy variable in the analyses[9] .

Multilevel Effects

The first step in modelling of hierarchically structured data is to examine the proportion of variance in the variables that may be due to the sample structure. To start this process it is important to identify the nested structure of the sample and determine the various grouping levels. This is not necessarily a straight-forward exercise. In the present study, some of the classes were taught by the same teacher within the same school, while other classes were taught by different teachers but were grouped within the same school, while other classes were the only ones included from a particular school. A simple nested structure of students grouped within classes that are themselves grouped within schools does not adequately describe the hierarchical structure of this data set. The ecological reality is far more complex than a simple nested structure suggests. One way of working with such a sample is through the use of a cross-classified model, however, the sample size of some studies may prevent the

[9] See p199 for a more detailed explanation.

use of such, and did so in the present study. Another way of recognising the complex nature of such a sample is to describe it in terms of a simple two-level structure of students and classes. The school level is not implemented, however, differences between schools are detected by including school as a dummy variable in the analyses. It was the latter method that was used in the present study.

Because whole classes were the primary sampling unit in this study, individual student data cannot be considered independent, and the next step in the analysis is to determine the strength of class effects on the student variables and constructs. This may be done through calculation of the intraclass correlation coefficient (ρ), which is the proportion of variance in a variable due to variation between classes. If the coefficient is significantly different from zero, then a multilevel model should be fitted so that the assumption of the independence of the data is not violated and statistical validity is preserved.

The proportions of variance in each of the variables of interest attributable to between-class mean differences and within-class (between student) differences can be established using two-level variance components models (Woodhouse, Rashbash, Goldstein and Yang, 1995). A variance components model is a simple form of multilevel regression which excludes explanatory variables and is used as a basic model for comparison with the variance explained in subsequent multilevel models which do include explanatory variables (Bryk & Raudenbush, 1992: 17).

Once the strength of the multilevel effects have been established through examination of the variance components model, MLn multilevel regression models are used to consider what proportion of the variance in a response (dependent) variable can be accounted for by explanatory variables at each level of the model. Since it is possible for student variables to have a class-specific dimension, regression coefficients can also vary randomly at class levels both in terms of the intercepts and slopes (Smith, 1996: 130).

The proposed causal model (Figure 5.2) was investigated by stepping backwards through the model. The outcome variables were entered as response variables and explanatory variables were fitted one at a time. If the explanatory variable was found to have a significant relationship to the response variable it was retained, otherwise, it was removed from the model. After finalising the model for each of the outcome variables, the intermediate variables were then entered as response variables and the process was repeated. Mathematical descriptions of both variance component models and random coefficient models are found in Appendix 4.

The current study makes use of iterative generalised least squares regression to analyse basic two-level models in both multilevel and multivariate-multilevel configurations. The former are used in recursive regression analyses, the latter are used in non-recursive models to estimate potential reciprocal relationships between sets of response variables. These models are described in detail in Chapter 8.

Summary

This discussion in this chapter has outlined the methodology of the present study by detailing the development of the database course, the development of the testing instruments, the implementation of the main study, and the analytical framework of the study. This discussion has emphasised the importance of different types of strategy instruction necessary for students to learn how to solve problems with information using databases. It has detailed the development of testing instruments and has provided a rationale for a two-stage approach to estimation consisting, firstly, of the development of one-factor congeneric models using LISREL8, and secondly, passing these models to MLn for the estimation of structural relationships. The next chapter explores the variables associated with the two levels of the analysis: student and classroom.

Chapter 7

Description and Development of Student and Classroom Variables

Introduction

Before proceeding to consider relationships between variables and constructs in the proposed model, it is desirable and informative to look at responses to the individual questionnaire items. These responses are of interest in themselves as they help profile the 541 students, 25 classrooms, and 12 schools that participated in the study.

This chapter is organised into two sections that consider student and classroom variables respectively. It also describes the development of various measurement constructs at the student level of the model. This was done via the generation of optimally weighted composites designed to minimise measurement error in the constructs.

Details of Student Variables

Student responses were collected from 12 schools in Newcastle and the Hunter region. Eleven of these schools were state high schools and one was a private high school. All of the students were enrolled in the year 9 and 10 Computing Studies course.

Data for the study were collected using a series of testing instruments, questionnaires and classroom observations. For discussion purposes, individual items have been grouped in eight categories: student background, use of computers, attitude to computers, knowledge, information processing, preferred approach to learning, flexibility in learning, and database processing. Descriptive statistics for all of the student variables are found in Table 7.1. This table also contains significant correlations ($p<0.05$) between the student variables that are referred to throughout the chapter.

Table 7.1 Correlations (x100) and Descriptive Statistics for Student Variables[1]

	Age (months)	Gender	Computer Experience	Achieving Approach	Deep Approach	Surface Approach	Adaptive Learning	Inflexible Learning	Irresolute Learning
Age			-09		11				
Gender			31						
Computer Experience				22	14				
Achieving Approach					56	53	51		
Deep Approach						41	64	21	22
Surface Approach							42	27	27
Adaptive Learning								14	26
Inflexible Learning									42
Mean	176.62	0.59	2.32	3.38	2.81	3.36	3.01	3.02	2.92
Median	176.00	1.00	2.56	3.45	2.82	3.38	3.06	3.02	2.93
S.D	4.87	0.49	0.67	0.79	0.65	0.57	0.73	0.70	0.67
Possible Range.	156-198	0 - 1	0.5 - 3.2	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5	1 - 5
N	493	540	492	437	433	434	427	426	427

[1] This table is continued on the following page.

Table 7.1 Correlations (x100) and Descriptive Statistics for Student Variables

	Like	Conf	PreHS	PreM	PstHS	PstM	Per	Datkw	PreIP	PstIP
Age					15				-11	-15
Gender	13	18	14				-16			
Experience	18	33							20	
Achieving	26	20	17							
Deep	27									
Surface	16			14	14	10				
Adaptive										
Inflexible								-14		
Irresolute									-15	
Computer Liking		12								
Computer Confidence			20					21	32	28
Pre-test High School					37				30	33
Pre-test Movies						31		14	21	22
Post-test High School						14			27	28
Post-test Movies									31	30
Personality								20	-18	-16
Database Knowledge									38	40
Pre-test Info. Process										80
Mean	2.62	3.34	0.53	0.65	0.68	0.86	0.76	0.82	0.62	0.76
Median	2.66	3.39	0.53	0.71	0.64	0.96	0.81	0.81	0.63	0.79
S.D.	0.62	0.54	0.22	0.29	0.20	0.22	0.25	0.19	0.22	0.20
Possible Range	1 - 4	1 - 4	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1	0 - 1
N	387	387	507	506	388	421	486	424	461	492

Student Background

The student background variables of age and gender were included in the study.

Age

The age of students in the study ranged from 13 years and 11 months to 16 years and 5 months with an average of 14 years and 9 months (S.D.=4.87 months). All students were in years nine and ten at school.

Gender

The sample was not divided equally among the sexes. Nearly 60 per cent (321) of the students who participated in the study were male, while just over 40 per cent (220) were female. Although considerable work has gone into addressing the problem of 'girls and computing' it would seem that in 1994 the gender gap in this subject had not completely closed as the males still enjoyed a majority status of 20 percentage points[2].

Student Background Constructs

Personality was the single student background construct included in the study.

Personality

Personality was included as a measure of student extroversion/introversion. Beamish (1988) used the Eysenck extroversion/introversion scale (Eysenck, 1964) and employed principal components factor analytic techniques to develop a 12-item single factor scale with a Cronbach alpha reliability of 0.69. In the present analysis, the same 12 items were used to develop a one-factor congeneric model using LISREL8 for the measurement of a personality construct. The procedures for the development of

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[2] Computing Studies was offered as an elective in all schools against other subject options that included History, Geography, and Art and Design.

multivariate constructs using LISREL8 to develop one-factor congeneric models were explained in Chapter 6.

Table 7.2 provides a summary of the characteristics of the one-factor congeneric model developed for Personality[3]. Detailed descriptions of the fitted one-factor congeneric models including parameter estimates, item reliabilities, factor score regressions, scale reliabilities and goodness-of-fit measures are provided in Appendix 3 (Table A3.1 on page A3.3).

Table 7.2 Fitted One-factor Congeneric Model for Student Personality Construct[a]

Student Constructs	No. of Items	χ^2(d.f., N)	Prob.	$\rho\xi_x$[b]	GFI[c]	RMR[d]
Personality	5	5.16 (4, 492)	0.207	0.885	0.997	0.058

Notes

a. Scale items, parameter estimates, item reliabilities, factor score regressions, scale reliabilities and more detailed goodness-of-fit statistics are found in Appendix 3 (Table A3.1 on page A3.3).

b. The $\rho\xi_x$ estimate of reliability obtained from the equivalent LISREL7 model.

c. GFI - LISREL8 goodness of fit index

d. RMR - LISREL8 root mean square residual

To achieve greater parsimony the scale was reduced to five items and the fit statistics indicated that these items were good indicators of the personality latent construct.

Results for Personality

Students responded to the personality items by using a two point response scale. This gave the personality construct a potential range from 0, indicating an introverted personality, through to 1, indicating an extroverted personality. The responses to the personality construct were negatively skewed and, on average, students in the study

[3] I am indebted to Smith (1996) for the format of this and similar tables.

were found to be extroverted with a mean response of 0.76 (S.D.= 0.25) and a median response of 0.81.

Student Intermediate Constructs

The student intermediate constructs of previous computer experience, approaches to learning, and flexibility in learning were included in the main study. These constructs are presage variables and, as they may be influenced by the student background variables and constructs, they have been termed intermediate constructs to indicate a sequencing of the presage variables included in the study. Consider each in turn.

Previous Computer Experience

Previous computer experience has been shown to have a large effect on students' ability to use computers and their attitudes to using them (Chen, 1986; Stubbs, 1994). In the present study, students were asked to report on their previous experience when working with computers at home, school, and elsewhere.

Computer Experience at Home

A large number of students were found to have a computer at home. Out of the 493 respondents to this question[4], 402 (82 per cent) reported that they had some form of computer at home. These computers were split into two main groups: personal computers and games computers. A personal computer was defined as a Commodore, Apple, Amiga, Macintosh, or IBM (including clones) while a games computer was defined as a Tandy, Atari, or Sega. Of the 402 students who reported having a computer at home, 334 (68 per cent of all respondents, 83 per cent of those with a computer) reported that they had a personal computer, while 187 (38 per cent of all respondents, 47 per cent of those with a computer) reported that they had a games computer. A total of 120 (24 per cent of all respondents, 30 per cent of those with a computer) reported that they had both.

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[4] Out of the original sample of 541 students, 493 responded to Instrument 1 with the remaining students being absent from the classroom when the instrument was administered. This represents an absentee rate of 8.9 per cent and although this is regrettable, it reflects the reality of research in real classrooms.

A breakdown of the number of personal computers in students' homes is found in Table 7.3. The numbers of students who have an IBM computer in their homes may even be greater than shown. Some of these students reported their IBM clone in the category of "other" as they didn't associate the brand name of their computer with IBM. Most of the students who indicated "other" did not specify what type of computer they had even though they were encouraged to do so.

Table 7.3 Personal Computers in Student Homes by Make.

Computer	Number	Percentage
Commodore	68	17
Apple	24	6
Amiga	48	12
Macintosh	16	4
IBM	233	58
Tandy	11	3
Atari	42	10
Sega	125	31
Other	66	16

The home ownership of computers was significantly gendered (F=17.231, df=(1,492); p=0.001). Of the 402 students who reported having a computer at home, 253 were males (79 percent of all males in the sample) and 159 were females (72 percent of all females in the sample). It would seem that males are more likely to have a computer at home than females.

Home Use

Students were asked to indicate how much they used computers at home. They responded using a five-point Likert scale: 1 'Never', 2 'Rarely' (less than once a month), 3 'Occasionally' (about once a month), 4 'Frequently' (about once a week), 5 'Very Frequently' (more than once a week). Overall, students across the entire sample reported that they used computers at home less than once a week with a mean of 3.63 S.D.=1.53) and a median score of 4.00. When this is restricted to those students who have a computer at home, they reported that on average they use their computers very frequently (more than once a week) with a mean of 4.29 (S.D.=1.05) and a median of 5.00.

Of those students who have a personal computer in their home, the biggest group has a personal computer only (53 per cent), however nearly one third of the students reported that they had both a personal computer and a games computer (30 per cent). A smaller group reported that they had a games computer only (17 per cent). An inspection of computer use by these groups shows that there were significant differences in use by students who had either a personal computer, a games computer, or both in their homes (F=7.011, df=(2,379); p=0.001). The use of computers by the various ownership groups is summarised in Table 7.4. Those students with both personal and games computers reported the highest use, followed by students with personal computers only, and then finally, students with games computers only.

Table 7.4 Ownership and Frequency of Use of Home Computers

	Home Computer	Personal Computer & Games Computer	Personal Computer only	Games Computer Only
Overall				
% of students	83	24	44	14
Mean Use	3.36			
Median Use	4.00			
S. D.	1.53			
With a home computer				
% of students	100	30	53	17
Mean Use	4.29	4.52	4.10	3.98
Median Use	5.00	5.00	4.00	4.00
S. D.	1.05	0.80	1.11	1.06

For those students who had a computer at home, the use of computers was found to be highly gendered, with boys using computers significantly more than girls at home (F=37.380, df=(1,401); p=0.000). It would seem that boys are not only more likely to have a computer at home, but they are also more likely to make use of one in the home.

Students in the study were asked about their main uses of computers at home. By far the most common use is the playing of computer games with 82 per cent of students who have a computer reporting this as a main activity. Game playing was found to be a highly gendered activity with boys being significantly more likely to use a computer to play games than girls (F=7.827, df=(1,401); p=0.005). The next highest reported use is Word processing with 42 per cent of students who have a computer reporting this as a main activity. Some students use their computers for other things with 13 per cent reporting graphics, and 10 per cent reporting programming, as main activities.

Interestingly, as well as games, programming was the only other computer activity found to be gender related, with boys being significantly more likely to program a home computer (F =8.270, df =(1,401); p =0.004). Table 7.5 summarises the main uses for home computers across the various ownership groups.

Table 7.5 Reported Main Uses of Home Computers

		Home Computer	Personal Computer & Games Computer	Personal Computer only	Games Computer Only
Word Processing	(%)	42	48	44	00
Graphics	(%)	13	18	12	09
Games	(%)	82	88	79	94
Programming	(%)	10	12	10	00
Other	(%)	15	03	05	00

It is of interest to notice that those students who have a 'games computer only' report very different main activities than the other two groups due to the limited performance range of these machines. They are designed to play games and do little else. The other two groups 'Personal Computer & Games Computer' and 'Personal Computer ' report similar usage figures although the first group generally had a higher percentage of students reporting computer use.

Home ownership of computers was found to be related to student attitudes to computers. Students who had a computer at home, were more confident in using computers (F=9.077, df=(1,360); p=0.003), and liked computers more (F=5.023, df=(1,360); p=0.026) than students who did not own a computer at home.

Computer Experience at School

At school, computers can be used in a number of ways at different times. Students reported their school use of computers in class time using the same five-point Likert scale described previously to determine Home Use (p166). On average students reported that they used computers in class time very frequently (more than once a week) with a mean of 4.6 (S.D.=0.72) and a median of 5.0. The use of computers at school was not influenced by the gender of the student. This High school use of computers is not surprising as all students in the present study used computers in their Computing Studies classes. Table 7.6 contains the percentage of students who reported various computer activities as a main use during class time[5].

Table 7.6 Reported Main Uses of School Computers (%)

	Classroom Use	Outside of Classroom Use
Word Processing	81	24
Graphics	13	05
Games	14	21
Programming	41	04
Other	08	07

When students were asked about their use of computers in school outside of their Computing Studies class there was a startling difference. Students reported a mean use of 2.0 (S.D.=1.1) and a median use of 2.00 indicating that they rarely (less than once a month) used computers in class outside of their Computing Studies classes. This use of computers in the school outside of Computing Studies classes was not related to the gender of the student.

A closer examination of the frequency distribution for this variable (Table 7.7) shows that nearly half (43 per cent) of the students in the study never use a computer outside of their Computing Studies class. A further 31 per cent rarely use a computer outside of Computing Studies. Only 13 per cent of students reported that they interact with a

[5] The percentages in rows and columns do not add to 100 per cent as some students reported more than one use of computers as a main use.

computer frequently at school outside of Computing Studies. This result indicates that computers are not being used as learning tools across the curriculum in most schools.

Table 7.7 Frequency of Computer Use in Class outside Of the Computing Studies Class

Use	Frequency	Percentage
Never	213	43
Rarely (less than once a month)	151	31
Occasionally (about once a month)	65	13
Frequently (about once a week)	48	10
Very Frequently (more than once a week)	16	3

Students were also asked to use the same 5-point Likert scale to report whether they used computers at school outside of the classroom. They reported a mean use of 1.7 (S.D.=1.0) and a median use of 1.0 indicating that they very rarely (less than once a month) use computers at school outside of the classroom. In fact, 57 per cent of the students reported that they never use a computer outside of class. Even though students reported a small amount of computer use outside of the classroom, this use was found to be highly gendered with boys being significantly more likely to use computers than girls (F=4.273, df=(1,539); p=0.039).

In summary, computer use at school mainly reflects the activities that teachers engage their students in during Computing Studies classes. The majority, if not all, of the students' computer use at school occurs during this time. Word processing dominates school computer use followed by programming. It would seem that teachers are still using very traditional methods of instruction and classroom activities for their students in Computing Studies. Word processing and games dominate students' main activities on the computer at school outside of the classroom, however, it should be remembered that at school very few students use computers during this time.

Other Use

Some students also gain experience in using computers at places outside of the home and school. Students were asked to indicate their 'other' use by the same five-point Likert scale. Students reported a mean of 2.4 (S.D.=1.0) and a median score of 2.0 indicating that they rarely (less than once a month) use computers at places other than home and school.

Students' use of computers at other places reflects similar use patterns to the previous two sections. Games dominate with 69 per cent of the students who are using computers at places other than home and school reporting computer games as their main use. Also, similar to previous patterns, the use of computers outside the home and school was found to be highly gendered, with boys being significantly more likely to use computers than girls (F=7.035, df=(1,539); p=0.008). Results for this computer use are summarised in Table 7.8.

Table 7.8 Reported Main Uses of Computers at Places other than Home and School (%)

	Other Use
Word Processing	10
Graphics	06
Games	69
Programming	02
Other	13

Previous Computer Experience Using Databases

Students participating in the study were asked to indicate how much they had used a database program before. They responded using the same five-point Likert scale discussed previously. Students reported a mean of 2.7 (S.D.=1.1) and a median of 3.0 indicating that they used databases occasionally (about once a month). This use was highly gendered with boys having used a database significantly more than girls (F=6.965, df=(1,539); p=0.009). Approximately one third of the students had never used a computerised database, and a further 20 percent of the students reported that they rarely used a database.

Seventy-two percent of the students who had used a database reported that they had been taught how to use one at school. This ranged from instruction in primary school through to year 9. When asked the level at which they were able to function, 60 per cent responded that they could use a database program to look for information and could do this without any help. Approximately 50 per cent said they could sort information on a database without any help, but only 37 per cent reported that they had ever solved problems that required them to use a database to find an answer.

Computer Experience Construct

Students came to the study with a variety of previous experiences with computers. All types of experience add to develop a confidence and facility of computer use. As discussed, students were asked at the commencement of the study about their previous experience with computers at home, at school, and at places other than home and school. They were also asked about their previous experience when working with databases. The responses to these items combine to indicate the previous experiences that students have had using computers. The current analysis uses LISREL8 to develop a one-factor congeneric model for the measurement of a computer experience construct. The Student Computer Experience Construct was computed from the maximally weighted, proportional factor score regression coefficients obtained from a one-factor congeneric model.

The fit statistics (summarised in Table 7.9 on the following page) indicate that the six items included in this scale were good indicators of a general computer experience latent construct. Detailed descriptions of the fitted one-factor congeneric models including parameter estimates, item reliabilities, factor score regressions, scale reliabilities and goodness-of-fit measures are provided in Appendix 3 (Table A3.2 on page A3.4).

As the computer experience construct is a composite of dichotomous and ordinal scales it does not have a natural metric. It ranges from a potential minimum value of 0.5 to a potential maximum value of 3.2 with 1.85 at the midpoint of the scale. On average, students in the study were found to be above the midpoint in reporting a mean of 2.32

(S.D.= 0.67), and a median of 2.56. This indicates that students came to the study with a reasonably good level of computer experience as measured by the computer experience construct.

Table 7.9 Fitted One-factor Congeneric Model for Student Computer Experience Construct [a]

Student Constructs	No. of Items	χ^2(d.f., N)	Prob.	$\rho\xi_x$ [b]	GFI [c]	RMR [d]
Computer Experience	6	9.47 (7, 541)	0.22	0.89	0.98	0.028

Notes

a. Scale items, parameter estimates, item reliabilities, factor score regressions, scale reliabilities and more detailed goodness-of-fit statistics are found in Appendix 3 (Table A3.1 on page A3.3).

b. The $\rho\xi_x$ estimate of reliability obtained from the equivalent LISREL7 model.

c. GFI - LISREL8 goodness of fit index

d. RMR - LISREL8 root mean square residual

Approaches to Learning

Approaches to learning were the second set of student intermediate constructs included in the study. As discussed in Chapter 3, students approach learning with a preferred style. Biggs and Moore (1993) suggest that students prefer a surface, deep, or achieving approach to their learning.

Approaches to learning are measured using the 36 item Learning Process Questionnaire and students respond to these items using a five-point Likert scale; 5 (this item is always or almost always true of me), 4 (this item is frequently true for me), 3 (this item is true for me about half the time), 2 (this item is sometimes true of me), 1 (this item is never or only rarely true for me).
The surface approach scale is made up of 12 items. For example, item 4:

> I tend to study only what's set; I usually don't do anything extra.

The deep approach scale consisted of 12 items. For example, item 2:

> I find that at times my school work can give me a feeling of deep personal satisfaction.

The achieving approach scale consisted of 12 items. For example, item 3:

> I try to obtain high marks in all my subjects because of the advantage this gives me in competing with others when I leave school.

In the current study, LISREL8 was used to develop one-factor congeneric models for the measurement of the Preferred Approach to Learning constructs. These constructs were computed from the maximally weighted, proportional factor score regression coefficients obtained from these one-factor congeneric models. Details of the Preferred Approach to Learning fitted one-factor congeneric models are found in Table 7.10.

Table 7.10 Fitted One-factor Congeneric Models for the Student Preferred Approach to Learning Constructs [a]

Student Constructs	No. of Items	χ^2(d.f., N)	Prob.	$\rho\xi_x$ [b]	GFI [c]	RMR [d]
Surface	10	30.31 (29, 440)	0.40	0.65	0.98	0.060
Deep	10	36.33 (30, 441)	0.20	0.80	0.98	0.059
Achieving	8	24.76 (18, 436)	0.13	0.85	0.98	0.043

Notes

a. Scale items, parameter estimates, item reliabilities, factor score regressions, scale reliabilities and more detailed goodness-of-fit statistics are found in Appendix 3 (Tables A3.3- A3.5 on pages A3.5-6).

b. The $\rho\xi_x$ estimate of reliability obtained from the equivalent LISREL7 model.

c. GFI - LISREL8 goodness of fit index

d. RMR - LISREL8 root mean square residual

Results for Approaches to Learning Scales

Students responded to the items in the Learning Process Questionnaire using the five point Likert scale outlined on the previous page. The range for each of the scales was 1 to 5. Students indicated that they prefer a surface approach slightly more than half the time by reporting a mean of 3.36 (S.D.=0.57) with a median response of 3.38 on the surface scale. Students scored a mean or 2.81 (S.D.=0.65) with a median score of 2.82 on the Deep scale indicating that they prefer a Deep approach less than half the time. On the achieving scale students scored a mean of 3.38 (S.D.=0.79) with a median response of 3.45 indicating that they prefer an achieving approach slightly more than half the time.

In summary, students reported nearly equal use of achieving and surface approaches to their learning. Both of these approaches, however, were significantly higher ($p<0.05$) than the use of the deep approach. It would seem that students are focused on passing their computer subject, and prefer to use surface approaches to accomplish this.

Flexibility in Learning

Students not only have a preferred approach to their learning (Biggs, 1987), but they also have different flexibilities in the use of learning skills (Cantwell, 1994). Cantwell and Moore (1996) found that mindful learners use adaptive executive strategy control through the use of planning and monitoring. On the other hand, those learners who adopt a 'mindless' approach to learning use the maladaptive modes of inflexibility in executive control and irresolute forms of executive control (Cantwell & Moore, 1996).

Students' flexibility in learning is measured using the 21 item Student Flexibility Questionnaire (Cantwell, 1994) that contains three scales. The Adaptive scale indicates how well students are prepared to consider new thinking and studying techniques as they adapt to task demands. The scale is made up of seven items. For example, item 4:

> Before starting work on a problem I like to think of different ways of attacking it.

The Inflexible scale indicates if students are always adopting the same way of approaching tasks. The scale is made up of seven items. For example, item 2:

> I find that I have one good way of doing my school assignments, and this works for me nearly all the time.

The Irresolute scale indicates if the students find different ways of approaching a thinking task confusing. The scale is made up of seven items.

For example, item 2:

> Sometimes I find different suggestions for ways of going about an assignment to be more confusing than helpful.

Students respond to the items in the questionnaire using the same five-point Likert scale as used in the Learning Process Questionnaire: 5 (this item is always or almost always true of me), 4 (this item is frequently true for me), 3 (this item is true for me about half the time, 2 (this item is sometimes true of me), 1 (this item is never or only rarely true for me).

The data from studies on students' flexibility in learning has mostly been analysed using principal components factor analytic techniques (for example, Cantwell, 1994). In the current study, LISREL8 was used to develop one-factor congeneric models for the measurement of the Flexibility in Learning constructs. These constructs were computed from the maximally weighted, proportional factor score regression coefficients obtained from the one-factor congeneric models. Details of the fitted one-factor congeneric models are found in Table 7.11 and detailed descriptions of the fitted one-factor congeneric models are provided in Appendix 3 (Tables A3.6-8 on pages A3.7-8).

Table 7.11 Fitted One-factor Congeneric Models for the Student Flexibility in Learning Constructs [a]

Student Constructs	No. of Items	χ^2(d.f., N)	Prob.	$\rho\xi_x$ [b]	GFI [c]	RMR [d]
Adaptive	7	12.14 (12, 423)	0.43	0.84	0.98	0.03
Inflexible	7	13.66 (11, 434)	0.25	0.93	0.98	0.04
Irresolute	7	14.50 (14, 436)	0.42	0.79	0.98	0.038

Notes

a. Scale items, parameter estimates, item reliabilities, factor score regressions, scale reliabilities and more detailed goodness-of-fit statistics are found in Appendix 3 (Tables A3.6-8 on pages A3.7-8).

b. The $\rho\xi_x$ estimate of reliability obtained from the equivalent LISREL7 model.

c. GFI - LISREL8 goodness of fit index

d. RMR - LISREL8 root mean square residual

The fit statistics indicate that the items included in the Adaptive, Flexible, and Irresolute scales were good indicators of the Flexibility in Learning latent constructs.

Results of Flexibility in Learning scales

The range for each of the flexibility scales is 1 to 5. Students recorded a mean response of 3.01 (S.D.=0.73) and a median response of 3.06 on the adaptive scale indicating that they adapted to the task demands about half the time. Of the two maladaptive scales, students reported a mean of 3.02 (S.D.=0.70) and a median response of 3.02 on the Inflexible scale indicating that they are inflexible in their learning strategies about half the time. Similarly, students reported a mean of 2.92 (S.D.=0.67) and a median score of 2.93 on the Irresolute scale indicating that they were unable to control strategic decisions slightly less than half the time.

In summary, students reported nearly equal use of adaptive and inflexible control, however, both of these measures were significantly ($p<0.05$) higher than the use of irresolute control. It is of interest to notice the nature of the correlations (Table 7.8) between students' Flexibility in Learning and their Approach to Learning. Adaptive strategy control, while being correlated with Surface approaches, formed the larger significant correlations with Deep and Achieving approaches. The maladaptive approaches to executive control (Inflexible and Irresolute) were not significantly correlated with Achieving approaches, but were significantly correlated to Surface approaches and to a lesser extent Deep approaches.

Student Outcome Constructs

Based on the review of the literature discussed in earlier chapters, a range of student outcome constructs were included in the study. These were Information Processing, Attitudes to Computers, Knowledge, and Database Processing. Consider each in turn.

Students Information Processing

The Information Processing constructs were intended to provide a measure of the procedural knowledge required by students when solving problems using computerised databases. These constructs included measures of Hypothesis Testing, Interpretation of Data, Sufficiency of Data, and Association of Data, and each warrants further consideration.

Hypothesis Testing

Students' ability to hypothesise relationships in sets of data is extremely important. To test this ability students were asked to form hypotheses for sets of categories and/or data.

For example, Item 2:

> A book on Movies contained information under the following headings:
>
> Name of the Movie
> Type of Movie (Western, Horror, Comedy etc...)
> Movie Director
> Year the movie was made
> Cost of the movie to make.
> Rating of the movie by a film critic.
>
> **Which one of the following conclusions could best be studied using this information only?**
>
> **A.** Silvester Stallone starred in many films and all were very popular.
> **B.** From 1935 movies were all in colour.
> **C.** Star Wars took three years to make.
> **D.** Oliver Stone directed mainly directed Comedy movies.

Six similar items combine to form the Hypothesis Testing scale.

Interpretation of Data

It is important that students are able to interpret the results of their searches and manipulations of data when working with information. The Interpretation of Data scale is made up of six items and is designed to test this.

For example, Item 11:

> A database was established that contained information about various countries of the world. The countries were sorted in order of how much money they made. It was then found that:
>
> **As the amount of money a country made increased, the number of people that work as farmers decreased.**

The best conclusion he can draw from this is:

A. Countries that have a lot of people working as farmers can produce a lot of food and their people rarely go hungry.
B. Those countries that can earn a lot of money also pay their farmers a lot of money.
C. The number of farmers that a country has, and the amount of money it makes, are not related.
D. Farming does not earn a lot of money for a country.

Sufficient Data

It is important for students to be able to recognise when they have sufficient data to test a hypothesis and reach a decision. The Sufficient Data scale is a five item scale designed to test this ability.

For example, Item 19:

A Movie database was constructed with the following fields:

Category (type of Movie)
Name of the Movie
Rating by a film critic
Director
Cast
Censor (G, PG, M, R)
Year of production
Colour or Black and White
Length
Cost
Earnings
Plot (Story of the Movie)

You wish to determine around what years movies made the move from black and white to colour. Which one of the following categories would contain enough information for you to be able to make a decision?

A. Name, Rating, Director, Plot.
B. Director, Year, Earnings, Colour
C. Cast, Colour, Name, Earnings.
D. Censor, Year, Length, Cost.

Association of Data

The Association of Data scale contains items that are designed to measure students' ability to recognise information associated with a problem and how that information may be best organised. For example, item 13:

I have a problem for you that may sound familiar; you have to solve problems like this one all the time. Here's the problem:

Your family has just driven into an unfamiliar town after a long drive, and you're dying to find a Pizza Hut! You stop at a petrol station to ask for directions. Here's what the petrol station attendant says:

You're in luck! There's a Pizza Hut right in town, and it's easy to get to. All the streets to the restaurants have lots of traffic lights to use as guides. First, follow the road that runs in front of the petrol station - that's Main street. Go through 4 traffic lights, then Main Street stops at a "T". Turn left onto Oak road. Go through 3 traffic lights. At the 4th set of traffic lights, take a right onto an unmarked street called Belvedere Drive. Take your first right. There are shops on both sides of the road. Pizza Hut will be on the left. You can't miss it!

Here's what YOU have to answer:

What information in these directions is NOT needed in order for you to find your way to Pizza Hut?

A. The number of traffic lights on Oak Road
B. Which way to go on Belvedere Drive
C. The number of traffic lights on Main street
D. Where to look for the Pizza Hut

and Item 6:

Let's suppose you were about to look for information about NASA's Space Shuttle program. If you were to look up some information in an encyclopedia which of the following categories of information would give you the LEAST USEFUL information?

A. US Space program
B. Nasa: 1970-1985
C. Astronauts
D. Rocketry

Developing the Information Processing Constructs

The information processing scales outlined in the previous pages were originally trialed in the Pilot study and analysed using principal components factor analytic techniques. Details of this analysis are found in Appendix 6. The current analysis used LISREL8 to develop one-factor congeneric models for the measurement of the information processing constructs. The Hypothesis Testing, Interpretation of Data, Sufficient Data, and the Association of Data Constructs were computed from the maximally weighted, proportional factor score regression coefficients obtained from one-factor congeneric models. Details of the fitted one-factor congeneric models for the student information processing constructs are found in Table 7.12.

Detailed descriptions of the fitted one-factor congeneric models are provided in Appendix 3 (Tables A3.9-12 on pages A3.9-11). The fit statistics indicated that the items included in the Hypothesis Testing scale, the Interpretation of Data scale, the Sufficiency of Data scale, and the Association of Data scale, were good indicators of the Information Processing latent constructs.

Table 7.12 Fitted One-factor Congeneric Models for the Student Information Processing Constructs [a]

Student Constructs	No. of Items	χ^2(d.f., N)	Prob.	$\rho\xi_x$ [b]	GFI [c]	RMR [d]
Hypothesis Testing	6	10.43 (8,369)	0.24	0.82	0.98	0.044
Interpretation of Data	6	10.1 (8, 370)	0.26	0.92	0.98	0.049
Sufficient Information	5	7.5 (5, 412)	0.19	0.75	0.98	0.048
Association of Data	7	15.2 (11, 412)	0.17	0.92	0.98	0.058

Notes

a. Scale items, parameter estimates, item reliabilities, factor score regressions, scale reliabilities and more detailed goodness-of-fit statistics are found in Appendix 3 (Tables A3.9-12 on pages A3.9-11).

b. The $\rho\xi_x$ estimate of reliability obtained from the equivalent LISREL7 model.

c. GFI - LISREL8 goodness of fit index

d. RMR - LISREL8 root mean square residual

Results of the Information Processing constructs

Each of the Information Processing constructs were administered as a pre-test at the commencement of the study and then as a post-test at the conclusion of the study. As the Information Processing constructs were made up of dichotomous variables, each of the scales ranged from 0 to 1. The results for these scales are shown in Table 7.13.

Table 7.13 Outcomes of Information Processing Constructs

Scales	Number of Items	Pre-test	Post-Test	Probability
Hypothesis Testing	6	0.66 (S.D.=0.30)	0.78 (S.D.=0.26)	($p<0.01$)
Interpretation of Data	6	0.71 (S.D.=0.29)	0.74 (S.D.=0.27)	($p<0.05$)
Sufficient Information	5	0.48 (S.D.=0.32)	0.65 (S.D.=0.33)	($p<0.01$)
Association of Data	7	0.57 (S.D.=0.26)	0.71 (S.D.=0.22)	($p<0.01$)

All scales showed a significant increase between the pre- and post-tests (2-tailed t-test, $p<0.05$). It would seem that working with computerised databases does assist students in developing their information processing skills as measured by these scales.

Second Order Factor Analysis

There were significant correlations between the information processing constructs (Table 7.14). In an attempt to achieve greater parsimony and avoid colinearity problems due to the significant correlations between the information processing constructs, a second order confirmatory factor analysis was performed to see if the first order constructs could form a second order construct. LISREL8 was used to develop a one-factor congeneric model for the measurement of a second order Information Processing construct. The size of the sample prevented the development of a single information processing construct directly from the items used in the various information processing scales.

The second-order Information Processing construct contains five items and included the four first-order information processing constructs and a fifth item relating to the organisation of information during problem solving. The second-order information processing construct was computed from the maximally weighted, proportional factor score regression coefficients obtained from this one-factor congeneric model.

Table 7.14 Correlations for Post-Test Information Processing Scales

	Hypothesis Testing	Interpretation of Data	Sufficient Information	Association of Data
Hypothesis Testing		0.41	0.42	0.26
Interpretation of Data			0.32	0.25
Sufficient Information				0.34
Association of Data				
Mean S.D. N	0.78 0.26 351	0.74 0.27 351	0.65 0.33 388	0.71 0.22 388

All correlations are significant at the 0.01 level.

Details of the fitted one-factor congeneric models for the combined Information Processing construct are found in Table 7.15.

Table 7.15 Fitted One-factor Congeneric Models for the Second Order Student Information Processing Construct [a]

Student Constructs	No. of Items	χ^2(d.f., N)	Prob.	$\rho\xi_x$ [b]	GFI [c]	RMR [d]
Information Processing	5	5.78 (4, 292)	0.22	0.80	0.99	0.064

Notes

a. Scale items, parameter estimates, item reliabilities, factor score regressions, scale reliabilities and more detailed goodness-of-fit statistics are found in Appendix 3 (Table A3.13 on page A3.12).

b. The $\rho\xi_x$ estimate of reliability obtained from the equivalent LISREL7 model.

c. GFI - LISREL8 goodness of fit index

d. RMR - LISREL8 root mean square residual

Detailed descriptions of the fitted one-factor congeneric models including parameter estimates, item reliabilities, factor score regressions, scale reliabilities and goodness-of-fit measures are provided in Appendix 3 (Table A3.13 on page A3.12). The fit statistics indicated that the items included in the second-order Information Processing scale were good indicators of a second-order Information Processing latent construct.

Results of the Second Order Information Processing Construct

The scale for Information Processing ranged from 0 to 1. Students averaged 0.62 (S.D.=0.22) on the pre-test for Information Processing and 0.76 (S.D.=0.20) on the post-test. This represents a significant increase in information processing over the duration of the course (p=0.01) and indicates that by the end of the course students had become much more successful at information processing.

Student Attitude To Computers

As discussed in Chapter 4, student attitudes to computers are important. Computers play an important role in the workplace and in schools and this role is set to increase. Attitudes to computers are important as they influence students' initial acceptance of information technologies, influence their future behaviour regarding computers, contribute to the quality of student life while at school and influence learning and achievement.

The current study made use of Computer Liking and Computer Confidence scales developed by Beamish (1988). Students were asked to respond to the 12-item questionnaire using a four-point Likert scale; 1 'Strongly Disagree', 2 'Disagree', 3 'Agree', 4 'Strongly Agree'. Students were not offered a neutral position and they were told to omit an item if they could not decide. This procedure is used to obtain higher scale reliabilities (Bourke & Frampton, 1992).

The current analysis used LISREL8 to develop one-factor congeneric models for the measurement of the student attitudes to computers constructs. The Student Computer Liking Construct and the Student Computer Confidence Construct were computed from the maximally weighted, proportional factor score regression coefficients obtained from the one-factor congeneric models. Details of the fitted one-factor congeneric models for the student attitudes to computers constructs are found in Table 7.16.

Table 7.16 Fitted One-factor Congeneric Models for the Student Attitudes to Computers Constructs [a]

Student Constructs	No. of Items	χ^2(d.f., N)	Prob.	$\rho\xi_x$ [b]	GFI [c]	RMR [d]
Computer Liking	6	19.95 (9, 392)	0.02	0.90	0.98	0.044
Computer Confidence	5	17.29 (9, 386)	0.04	0.90	0.97	0.049

Notes

a. Scale items, parameter estimates, item reliabilities, factor score regressions, scale reliabilities and more detailed goodness-of-fit statistics are found in Appendix 3 (Tables A3.14-15 on pages A3.13-14).

b. The $\rho\xi_x$ estimate of reliability obtained from the equivalent LISREL7 model.

c. GFI - LISREL8 goodness of fit index

d. RMR - LISREL8 root mean square residual

Detailed descriptions of the fitted one-factor congeneric models including parameter estimates, item reliabilities, factor score regressions, scale reliabilities and goodness-of-fit measures are provided in Appendix 3 (Tables A3.14-15 on pages A3.13-14). The fit statistics indicated that the six items included in the Computer Liking scale and the five items in the Computer Confidence scale were good indicators of the Computer Liking and Computer Confidence latent constructs. Each of the constructs retained the metric of the original items.

Computer Liking

The Computer Liking construct had a possible range of 1 to 4 with a mid-point of 2.5. It contained items where students indicated how much they liked working with computers.

For example:

Item 7 - I like, or would like, learning on a computer.

Students indicated that generally they liked working with computers when they reported a mean of 2.63 (S.D.=0.62) and a median of 2.66 on the Computer Liking scale.

Computer Confidence

The Computer Confidence construct had a possible range of 1 to 4 with a mid-point of 2.5. It contained items where students indicated how much confidence they had working with computers.
For example:

Item 10 - I can only use a computer for very easy tasks.

Students reported a mean of 3.34 (S.D.=0.54) and a median of 3.39 on the Computer Confidence scale indicating that generally they are confident when working with computers.

Overall, students reported positive attitudes to computers with Confidence being significantly higher than Liking ($p<0.01$).

Student Knowledge

As discussed in Chapter 4, studies on expertise across many domains have identified that experts have a highly developed knowledge base. Indeed, for many years theorists have believed that such a knowledge base is a prerequisite for efficient problem solving and information processing (deGroot, 1965). It is of substantial interest, therefore, to consider the level of knowledge that students acquire from database activities. During the course of this study students worked with several databases. The Knowledge constructs indicate the level of content knowledge students acquired of the various databases used throughout the course.

The High School Knowledge and Movie Knowledge scales developed in the Pilot study were used in the Main study. The current analysis used LISREL8 to further develop one-factor congeneric models for the measurement of the student knowledge constructs. The High School Knowledge Construct and the Movie Knowledge Construct were computed from the maximally weighted, proportional factor score regression coefficients obtained from one-factor congeneric models. Details of the fitted one-factor congeneric models for the student knowledge constructs are found in Table 7.17.

Table 7.17 Fitted One-factor Congeneric Models for Student Knowledge Constructs [a]

Student Constructs	No. of Items	χ^2(d.f., N)	Prob.	$\rho\xi_x$ [b]	GFI [c]	RMR [d]
High School Knowledge	4	2.34 (1, 331)	0.13	0.95	0.99	0.037
Movie Knowledge	6	11.67 (9, 373)	0.23	0.88	0.98	0.071

Notes

a. Scale items, parameter estimates, item reliabilities, factor score regressions, scale reliabilities and more detailed goodness-of-fit statistics are found in Appendix 3 (Tables A3.16-17 on pages A3.15-16).

b. The $\rho\xi_x$ estimate of reliability obtained from the equivalent LISREL7 model.

c. GFI - LISREL8 goodness of fit index

d. RMR - LISREL8 root mean square residual

Detailed descriptions of the fitted one-factor congeneric models are provided in Appendix 3 (Tables A3.16-17 on pages A3.15-16). The fit statistics indicated that the items included in the High School Knowledge scale and the items included in the Movie Knowledge scale were good indicators of the Knowledge latent constructs.

High School Knowledge

High School Knowledge concerned student knowledge of the content of the High School database used during the database course. All the items were multiple choice format.

For example, item 3:

> Which age group at school do you think is more likely to have been in contact with the police?
>
> **A.** 12 - 13 years
> **B.** 14 - 15 years
> **C.** 16 - 17 years
> **D.** 18 - 19 years

A copy of the full questionnaire is found in Appendix 2.

The scale originally contained nine items. The items that did not contribute significantly to the construct were removed and this reduced the scale to four items. The scale was administered as a pre-test at the commencement of the course before the students had worked with the High School database, and again as a post-test at the conclusion of the lessons using the High School database. As the scale is made up of dichotomous items, the range for the High School Knowledge construct is 0 to 1. Students averaged 0.53 (S.D.=0.22) on the pre-test and 0.68 (S.D.=0.20) on the post-test, showing a significant improvement between the two tests ($p=0.01$) in their knowledge of the content of the High School database after completing the database activities.

Movie Knowledge

Student knowledge of the content of the Movie database used during the course was measured using the Movie Knowledge construct. The scale originally contained nine items, however, this was reduced to six items once the items that did not contribute significantly to the construct were removed. All items were in multiple choice format. For example, item 5:

> What has been the most popular movie of all time up to the release of Jurassic Park in 1993?
>
> **A.** E.T.
> **B.** Star Wars
> **C.** Superman
> **D.** Rain Man

Similar to the High School Knowledge scale, the Movie construct was made up of dichotomous items and the range for the Movie Knowledge construct is 0 to 1. The scale was administered as a pre-test at the commencement of the database course, and again as a post-test at the conclusion of the lessons using the Movie database. Students averaged 0.65 (S.D.=0.29) on the pre-test and 0.86 (S.D.=0.22) on the post-test, thereby showing a significant improvement between the two tests (p=0.01) in their knowledge of the content of the Movie database after completing the database activities.

As there was a significant increase in student knowledge of the content of both of the databases used in this study, it would seem that students were able to acquire content knowledge when they work with computerised databases.

Database Knowledge

The use of Database Knowledge construct was designed to measure students' knowledge of databases and how well students could use database software to solve problems. These items in the Database Knowledge instrument covered a range of questions about databases as well as some practical database activities. For example, Item 4:

> A school database was made up of all the students' names and addresses.
> What is the smallest piece of information?
>
> **A.** Disk
> **B.** File
> **C.** Database
> **D.** Record

In the current study, LISREL8 was used to develop a one-factor congeneric model for the measurement of the Database Knowledge construct. The items included in the testing instrument were developed during the study. The construct was computed from the maximally weighted, proportional factor score regression coefficients obtained from this one-factor congeneric model. Details of the fitted one-factor congeneric model for the Database Knowledge are found in Table 7.18. Detailed descriptions of the fitted one-factor congeneric models are provided in Appendix 3 (Table A3.18 on page A3.17). The fit statistics indicated that the 6 items included in the scale were good indicators of the Database Knowledge latent construct.

The Database Knowledge scale had a range of 0 to 1 and students scored a mean of 0.82 (S.D.=0.19) with a median response of 0.81 indicating that they had a high level of database knowledge and skills at the end of the course.

Table 7.18 Fitted One-factor Congeneric Model for the Student Database Knowledge Construct [a]

Student Constructs	No. of Items	χ^2(d.f., N)	Prob.	$\rho\xi_x$ [b]	GFI [c]	RMR [d]
Database Processing	6	10.22 (8, 410)	0.25	0.83	0.98	0.09

Notes

a. Scale items, parameter estimates, item reliabilities, factor score regressions, scale reliabilities and more detailed goodness-of-fit statistics are found in Appendix 3 (Table A3.18 on page A3.17).

b. The $\rho\xi_x$ estimate of reliability obtained from the equivalent LISREL7 model.

c. GFI - LISREL8 goodness of fit index

d. RMR - LISREL8 root mean square residual

Details of Classroom Variables

Classroom observational data were collected for 22 of the 25 classrooms in the sample over a series of five lessons (110 observations in total)[6]. Each lesson was observed by the principal researcher and recorded using the Classroom Observation Instrument developed for this purpose. This instrument was used to gather data on classroom background variables and lesson variables and a copy of it is found in Appendix 2.

[6]A complete set of observational data was not collected for three of the classrooms due to the ill-health of the teachers of those classrooms.

Classroom Background Variables

The initial part of the classroom observations involved collecting data on the classroom background variables. These included the number of students in each class, the computer hardware and software used in each class, and whether the class was using the heuristic as part of the database course. Consider each in turn.

Number of students in the class

The number of students in each of the classrooms ranged from a minimum class size of 11 through to a maximum class size of 28. Overall, classes contained on an average 22.3 (S.D.=3.6) students.

Computer Hardware and Software

Various combinations of hardware and software were used in the classrooms during the study. All classrooms used personal computers with an integrated software package. Eight of the classrooms had Macintosh computers using Clarisworks Version 2, two classrooms had Apple IIe computers using Appleworks, and 13 classrooms had IBM compatible computers with seven of these classrooms using Microsoft Works 2, and six classrooms using Microsoft Works 3.

The software that the classrooms used was related to learning outcomes. Different classes used different software programs and significant differences in the two database content knowledge outcomes was related to this software use. In both post-test High School Knowledge (F=8.496, df=(3,387); p=0.000), and post-test Movie Knowledge (F=8.272, df=(3,420); p=0.000), students using Microsoft Works 2 performed significantly worse than students using the other software packages. This may be related to the operation of the database with Microsoft Works 2 being command driven, rather than menu driven, making it harder to use. Previous studies have found that command language structure generates feelings of uncertainty that do not occur when using menus (Spavold, 1989). Students using Microsoft Works 2 may carry a greater cognitive load as they work with the syntax of the commands, especially when creating queries. It would seem that this may restrict the amount of content knowledge that they are able to derive from using the database. On the other hand, students using Clarisworks performed significantly better than the other students on the post-test Movie Knowledge, and developed better Database Knowledge and skills (F=10.973, df=(3,423); p=0.000). Anecdotal evidence from teachers and students suggests that Clarisworks was the easiest of all the database software to use.

Heuristic

The use of the DEAL heuristic to scaffold student learning was discussed in Chapter 4. Thirteen of the 25 classrooms in the study made use of this heuristic and these classrooms were randomly assigned using a lottery method.

Classroom Lesson Variables

The classroom lesson variables of modelling, peer interaction, direct instruction, teacher engagement, students on task, and implementation, were all recorded using an ordinal scale that ranged from 1 (of no importance) through to 5 (extremely important). Descriptive statistics and significant correlations ($p<0.05$) for all of the classroom lesson variables are found in Table 7.19 on the following page.

Modelling

Modelling of problem solving techniques and strategies has been suggested as an effective way of communicating these skills and strategies to students (Collins et al., 1989). The modelling variable is a measure of the importance of teachers' use of modelling to the success of the database lessons. On average teachers scored 1.60 (S.D.=0.64) with a median of 1.40 indicating that teachers' use of modelling was of little importance during the database lessons. One reason for this could have been the logistics of modelling in the classroom. Of the 22 classrooms observed in the study, only two had any way of projecting the display of a computer onto a screen so that the entire class could watch the teacher at work. The average observation score for teacher modelling in these two classes was much higher at 3.31. The teachers in the other classrooms found modelling difficult as they had no effective way of modelling to the entire class. Of course teachers could have modelled problem solutions to smaller groups of students standing around a personal computer, however, because this is a fairly inefficient use of time with the same demonstration having to be repeated several times around the room, teachers seemed not to do this.

Table 7.19 Correlations (x100) and Descriptive Statistics for Classroom Lesson Variables

	Modelling	Peer Interaction	Direct Instruction	Heuristic	Teacher Engagement	Students On-Task	Implement
Modelling		25	41	22	26	36	22
Peer Interaction			49		78	59	89
Direct Instruction				24	75	48	55
Heuristic						-14	-19
Teacher Engagement						48	73
Students On-Task							73
Mean	1.60	3.03	2.97	0.57	3.64	3.60	3.06
Median	1.40	3.20	2.80	1.00	4.00	3.80	3.00
S.D.	0.64	0.80	0.77	0.50	0.83	0.75	1.10
Possible Range	1 - 5	1 - 5	1 - 5	1 - 2	1 - 5	1 - 5	1 - 5
Reliability[b]	0.91	0.84	0.77	-[c]	0.86	0.82	0.92
N	110	110	110	110	110	110	110

Notes

a. Only correlations that are significant at p=0.05 are shown.

b. The reliability coefficient recognises that the behaviour of teachers does vary over different lessons, and provides an estimate of the degree to which teachers are consistent in behaviour during different lessons with the same class. The reliability coefficient for each measure obtained from the classroom observations was determined using:

$$\frac{MS_t - MS_w}{MS_t}$$

where MS_t = mean square variation between teachers
MS_w = mean square variation within teacher behaviours
(Rowley, 1976: 54; Bourke, 1984: 89).

c. Dichotomous variable and therefore reliability was not calculated.

Peer Interaction

Cooperative learning through peer interaction is thought to enhance students' problem solving abilities (Volet, 1991; Jackson, Fletcher, & Messer 1992). In a group, students work within a rich cognitive environment as they share ideas, discuss strategies, support each other, and evaluate outcomes. In the present study students were encouraged to work in groups with their peers. The peer interaction variable is a measure of the contribution that peer interaction made to the success of the lesson being observed. This took into account the amount of time that students spend working with their peers and the quality of this interaction. On average, classrooms scored 3.03 (S.D.=0.80) with a median score of 3.20 indicating that peer interaction was important to the database lessons.

Direct Instruction

One way in which teachers can help students solve problems is to give them direct instruction in how to go about the problem solving process (Haller, Child, & Walberg, 1988). The Direct Instruction variable is a measure of the significance of the teacher's use of this teaching method in the classroom. On average teachers scored 2.97 (S.D.=0.77) with a median score of 2.80. This is marginally less than half way on the scale indicating that teachers' use of direct instruction was of some importance to the database lessons.

Teacher Engagement

The level of teacher engagement in the database activities during the lesson was recorded as a five-point ordinal variable. On average teachers scored 3.64 (S.D.=0.83) with a median of 4.00 indicating that they were fully engaged in the database activities most of the time.

Student On-task

The amount of time that students remained on task when working on the database activities was recorded as an ordinal variable. On average, students scored 3.60 (S.D.=0.75) with a median score of 3.80 indicating that they remained on task most of the time.

Implementation

It was important to estimate how successful the teachers were in implementing the database course as outlined in the course booklet. The implementation variable was used to do this and was measured during the classroom observations as the principal researcher observed how the various teachers were implementing the database lessons and how these lessons compared to those outlined in the database course booklet. Attention was paid to the amount of time devoted to each of the database activities and particular attention was paid to the teaching methods used during the presentation of the database course.

On average teachers scored 3.06 (S.D.=1.10) with a median score of 3.00 indicating that they were slightly above the half way mark of 3.00 in the scale. A closer look at the implementation variable shows an interesting breakdown. During the study two groups of teachers were asked to implement two slightly different courses. The first made use of a heuristic to scaffold students during the problem solving process. The second did not make use of the heuristic, but was the same as the first course in all other respects. The average score for implementation for teachers using the first course that made use of the heuristic, was 2.77 (S.D.=0.90) with a median of 2.40. The average implementation for teachers using the second course without the heuristic was 3.94 (S.D.=0.80) with a median of 4.20. This represents a significant difference ($p=0.05$) in implementation between the two groups of classrooms, with teachers using the course without the heuristic being significantly better at implementing the course than those using the heuristic. This difference reflects the fact that none of the teachers in the study had made use of a heuristic before this study and although the teachers who used the heuristic were trained in its use, they often failed to implement it successfully in their classrooms.

Summary

This chapter has examined the student and classroom variables that were collected by the testing instruments and classroom observations as a preliminary step before proceeding with subsequent analyses. Most significantly, the development of the 18 one-factor congeneric models, as explained in this chapter, has facilitated the aim of developing parsimonious models used to examine possible causal relationships.

The chapter that follows discusses the development and results of models that link the student and classroom variables and constructs. These models will be used to explore the relationships posited to exist in Chapter 5.

Chapter 8

Learning in the Computer Classroom: Analysing the Model

Introduction

The previous chapter provided detailed descriptions of the variables and constructs included in the present study and some of the more basic relationships between them. Attention is now turned to the more complex patterns of relationships that exist between these variables. The hypothesised relationships between the student background measures, the classroom measures, and the outcomes-of-learning measures have been summarised in the model for the analysis (Figure 5.2). This chapter provides a detailed description of the relationships found to exist between the student background variables and constructs, the classroom context variables, and the outcome constructs based on the results obtained from the analysis of the model using multilevel and multivariate structural equation modelling techniques.

In the current analysis, the multilevel program MLn (Rasbash & Woodhouse, 1995) was used to assess the strength of relationships between the variables and constructs included in the study. The analysis proceeded in three stages. Firstly, multilevel variance components models (Bryk & Raudenbush, 1992) were used to determine the proportion of variance of discrete variables and multivariate constructs arising from differences between classrooms. Secondly, the model[1] was tested through the development of MLn multilevel models (Goldstein, 1995) for each of the outcome constructs. Separate models were tested for each of these due to the desire to investigate the complexity of relationships between the background, intermediate, and outcome variables and constructs, and also a desire to investigate a number of cross-level influences in the models. Finally, in the third stage of the analysis, a multivariate-multilevel model (Goldstein, 1995) was developed to test relationships that were hypothesised to exist between the four outcome constructs.

[1] For details of development of the model see Chapter 5.

Background to the Model for Analysis

It has been claimed that the use of computers in the classroom can provide flexibility for individual students, present information in new and relevant ways, motivate students, encourage analytical and divergent thinking, and offer potential for effective group work (ACT Department of Education and Training and Children's, Youth & Family Services Bureau, 1996). Computerised databases are one tool that may be used in the classroom to accomplish this (Ehman et al., 1992; Riding & Chambers, 1993; Maor & Taylor, 1995; Leader & Klein, 1996).

Beamish (1988) investigated student attitudes to computers and developed a recursive model that described the relationship between the student presage factors of age, gender, personality, and computer experience, and the product factors of attitudes to computers. Within this model there was no attempt to investigate the process factors that exist in the classroom. The current study extends the model to examine the learning environments that exist within classrooms when students work with computerised databases. It expands the presage factors to include student's preferred approach to their learning (Biggs, 1987) and their flexibility in learning (Cantwell, 1994). It includes teaching process factors, and expands the product factors to include knowledge outcomes and information processing outcomes as well as attitude outcomes.

General Model and Approach to the Analysis

From the literature it can be postulated that student background, classroom experiences and teaching practices can affect student learning (Biggs & Moore, 1993: 448). The particular relationships of interest in the present study are presented in Figure 5.2. The analysis of the data was designed to shed light on the question of whether or not these relationships are consistent with the data collected during this research project.

The analysis consisted of a series of tests of paths in the proposed hierarchical linear model. The methodology used to test the model and determine if it was a good description of the data is described by Smith (1996: 206) who followed the model-generating approach described by Joreskog and Sorbom (1993a) and the theory-trimming approach of Pedhazur (1982: 616). Using this approach, the researcher specifies a tentative theory-driven model which, on the basis of the model's fit to the data, is successively modified and retested until, on a combination of statistical and substantive criteria, an optimal fit is obtained. Non-significant paths in the model are deleted, and paths that are statistically significant but trivial in theoretical terms are also deleted.

Stage 1 of The Analysis: Multilevel Effects in the Data

As this research study examined student learning within classrooms, it was suspected that students would not provide the data-independence required of multivariate analysis, rather, that student responses to questionnaires would be influenced by their teacher and other students in their class. Students who are in the same class are, on average, likely to behave in ways similar to other students in their class. Also, students who are taught by the same teacher are more likely to undergo similar learning experiences than students who are taught by a different teacher in a different class. Some of the classrooms were grouped in schools and it was suspected that independence of student data would be further compromised by these groupings. Classes taught at the same school are more likely to be similar than classes taught at different schools as they are part of the same community and share the physical plant and use the same equipment. Also it is expected that teachers within a school would share common experiences and values and be more similar in their teaching than those from different schools.

The validity of conclusions reached using statistical techniques that do not take into account the clustering that occurs within a sample are prone to problems of aggregation bias, undetected heterogeneity of regression, miscalculation of estimates of parameters and their standard errors, and other problems arising from model misspecification due to lack of independence between variables at the different clustering levels (Rowe, 1993, Smith, 1996: 111).

In the current study there were 541 students in 25 classes, taught by 17 teachers in 12 schools. When those students who had missing data in their data record were removed[2], the sample was reduced to 293 students[3] in 21 classes, taught by 16

[2] LISREL and MLn require complete data sets.

teachers in 11 schools. It is expected that data from the sample will exist in a hierarchical, nested structure. One possible structure to consider is students at level-1, classrooms at level-2, teachers at level-3, and schools at level-4 as shown in Table 8.1.

In an optimal balanced multilevel design there would be approximately equal numbers of classes in each school and equal numbers of students in each class (Smith, 1996: 320). It was not possible to achieve this sample structure in the present study due to time and resources. More importantly, some researchers argue that such a sample would have reduced ecological validity (Smith, 1996: 320). Mok (1997) estimated sample size requirements for unbalanced designs and these requirements were met in this study.

Table 8.1 Summary of the Multilevel Nature of the Data (4 levels)

Level- 4 Units:	**11**	**Schools**				
Level- 3 Units:	**16**	**Teachers**				
Level -2 Units:	**22**	**Classes**				
Level -1 Units:	**293**	**Students**				
School no.	10	12	13	14	15	16
Teachers	1	1	2	1	1	1
Classes	1	1	2	3	2	2
Students	12	19	15	30	24	42
School no.	17	18	19	20	21	
Teachers	1	2	3	1	1	
Classes	1	2	4	1	2	
Students	13	29	53	16	36	

Closer examination of the sample used in the present study reveals that its structure is more complex than the simple proposed nested structure in Table 8.1. Some of the classes are taught by the same teacher within the same school, while other classes are taught by different teachers but are grouped within the same school. Other classes are the only ones included from a particular school. The structure proposed in Table 8.1 does not adequately describe the hierarchical structure of the data. The ecological reality is far more complex than the initial simple nested structure suggests.

[3] Following the findings of Brown (1994), PRELIS2 similar response pattern imputations (Joreskog & Sorbom, 1993c) were used to recover 12 cases with missing values for items included in the scales in the study.

Due to the complex nature of the hierarchical structure of the data, and due to the small size of the sample it was decided to describe the multilevel structure of the data in terms of a two level model with students at level-1 and classes at level-2[4]. School variables were introduced into the model as dummy variables to recognise possible school effects and to test for significant school differences at these levels during the analysis. The proposed levels for the analysis are shown in Table 8.2.

Table 8.2 Summary of the Multilevel Nature of the Data (2 levels)

Level -2 Units: 21 Classes
Level -1 Units: 293 Students

Class no.	1011	1211	1311	1321	1411	1412	1413
Students	12	19	15	4	8	10	12
Class no.	1511	1512	1611	1612	1711	1811	1821
Students	16	8	21	21	13	16	13
Class no.	1911	1921	1922	1931	2021	2111	2112
Students	14	13	11	15	16	15	21

Variance Components Model Analyses

A first step in modelling of hierarchically structured data is to examine the proportion of variance in the variables that may be due to the sample structure. Student responses can not be considered independent, and it is important to determine the strength of class-effects on the student variables and constructs. The intra-class correlation coefficient (ρ) is the proportion of variance of a variable due to variation between classes. If ρ is significantly different from zero then a multilevel model should be fitted so that the assumptions of the independence of the data is not violated and statistical validity is preserved.

The proportion of the variance in the student background variables and constructs and student outcome constructs attributable to between class differences and within class (between student) differences can be established using two-level variance components models (Woodhouse, Rashbash, Goldstein & Yang, 1995). A variance components

[4] The use of a cross classified model was explored however the small size of the data set prohibits this.

model is a simple form of multilevel regression which excludes explanatory variables and is used as a basic model for comparison between subsequent multilevel models which do include explanatory variables (Bryk & Raudenbush, 1992).

Rowe, Hill & Holmes-Smith (1995) show how the simple variance components model may be written in two parts:

a within classes part:

$$Y_{ij} = \beta_{0j} X_0 + e_{ij} \qquad [8.1]$$

and a between classes part:

$$\beta_{0j} = \gamma_{00} + \mu_{0j} \qquad [8.2]$$

where Y_{ij} = the outcome (response) variable for students *i* in class *j*

X_0 = 1; so that no explanatory variable is fitted into the model

β_{0j} = the mean outcome (y-axis intercept) for class *j*

γ_{00} = the grand mean outcome for all classes

e_{ij} = student-level random residual for student *i* in class *j*

μ_{0j} = class-level random residual for class *j*

Now combining [8.1] and [8.2], a single version of the model can be written as:

$$Y_{ij} = \gamma_{00} + (\mu_{0j} + e_{ij}) \qquad [8.3]$$

The distributional assumptions for the random coefficients are:

$\mu_{0j} \sim NID\ (0, \sigma_0^2)$, where σ_0^2 is the variance of the level 2 (class) residuals μ_{0j};

$e_{ij} \sim NID\ (0, \sigma_e^2)$, where σ_e^2 is the variance of the level 1 (student) residuals e_{ij};

and μ_{0j} and e_{ij} are normal and independent (NID).

The total variance of the response variable as calculated from [8.3] is:

$$Var\ (Y_{ij}) = Var\ (\mu_{0j} + e_{ij}) = \sigma_0^2 + \sigma_e^2 \qquad [8.4]$$

Since the random parameters are measured at different levels of the hierarchy they are assumed to be uncorrelated, and the intra-class correlation is given as:

$$\rho = \sigma_0^2 (\sigma_0^2 + \sigma_e^2)^{-1} \qquad [8.5]$$

The intra-class correlation provides an estimate of the proportion of total variance between students that is accounted for by variation between classes.

The student background variables and constructs, and the student outcome constructs were all tested using variance components models. These analyses were performed using the multilevel analysis computer program MLn (Rasbash & Woodhouse, 1995). Results for the unstandardised variance components models of the two presage variables and 11 presage constructs, showing the grand means (γ_{00}), student level random coefficients (σ_0^2), class-level random coefficients (σ_e^2) and the intra-class correlations (ρ) are found in Table 8.3. Results for the unstandardised variance components models of the six student outcome constructs are found in Table 8.4. Unstandardised scores were used in the variance components model to allow comparison between student background constructs and student outcome constructs in terms of the original scale metric.

From Table 8.3 the proportions of the between class variance for the student background variables of Age (32.1%), Gender (15.7%), and the student presage constructs of Pre-test Movie Knowledge (10.3%) and Pre-test Information Processing Ability (20.0%) were statistically significant. Also from Table 8.4 the proportions of between class variance for the student outcome constructs of Post-test High School Knowledge (11.0%), Post-test Movie Knowledge (18.6%), Post-test Information Processing Ability (20.0%), and Knowledge about Databases (23.3%) were statistically significant. As these variables have significant between class variance, it is essential to use multilevel analyses so that appropriate statistical and substantial conclusions can be drawn from the analysis of subsequent models that include them.

The within- and between-class variation of variables and constructs may be displayed graphically. For example, the Computer Experience construct is displayed graphically in Figure 8.1. In a similar way the within- and between-class variation in variables and constructs that showed significant between class differences are displayed in Appendix 4.1. These include: Age, Gender[5], Pre-test Information Processing, Post-test Information Processing, Post-test High School Knowledge, Pre-test Movie Knowledge, Post-test Movie Knowledge, and Knowledge about Databases. These

[5] Gender has been included even though it is a dichotomous variable. Single gender classes appear on this graph as single dots and classes with both genders have the same within-class distribution. The between-class distribution does give an indication of the difference in the ratios of the genders in the various classes.

figures (A4.1 to A4.9) offer a summary of both student and class distributions for included variables in all 22 classes.

Table 8.3 Variance Components Models for Student Presage Variables and Constructs

Scale	Grand Mean γ_{00}	Between Class Variance σ_0^2	Within Class Variance σ_e^2	Total Variance $\sigma_T^2 = \sigma_0^2 + \sigma_e^2$	% of variance between classes	% of variance within classes	Intra-class correlation (ρ)
Age	176.60 (0.66)	7.80* (2.79)	16.54 (1.42)	24.34	32.05	67.95	0.320*
Gender	0.564 (0.052)	0.039* (0.017)	0.209 (0.018)	0.248	15.73	84.27	0.157*
Personality	0.763 (0.019)	0.003 (0.002)	0.057 (0.005)	0.060	5.00	95.00	0.050
Computer Experience	2.341 (0.058)	0.040 (0.022)	0.394 (0.034)	0.434	9.22	90.78	0.092
Deep	2.803 (0.039)	0.000 (0.000)	0.444 (0.037)	0.444	0.00	100.00	0.000
Surface	3.373 (0.033)	0.001 (0.007)	0.309 (0.026)	0.310	0.32	99.68	0.003
Achieving	3.412 (0.047)	0.004 (0.014)	0.578 (0.049)	0.582	0.69	99.31	0.007
Adaptive	3.003 (0.042)	0.000 (0.000)	0.523 (0.043)	0.523	0.00	100.00	0.000
Irresolute	2.868 (0.051)	0.024 (0.017)	0.424 (0.036)	0.448	5.36	94.64	0.054
Inflexible	2.985 (0.041)	0.004 (0.011)	0.438 (0.037)	0.442	0.91	99.09	0.009
Personality	0.763 (0.019)	0.003 (0.002)	0.057 (0.005)	0.060	5.00	95.00	0.050
Pre-test - Information Processing	0.608 (0.024)	0.009* (0.004)	0.037 (0.003)	0.046	19.57	80.43	0.200*
Pre-test High School Knowledge	0.527 (0.024)	0.004 (0.004)	0.103 (0.009)	0.107	3.74	96.26	0.037
Pre-test Movie Knowledge	0.646 (0.025)	0.008* (0.004)	0.070 (0.006)	0.078	10.25	89.75	0.103*

Note: (a) Statistical significance at $p<0.05$ by univariate two tailed tests are indicated by a *
(b) Sample size = 293

Table 8.4 Variance Components Models for Student Outcome Constructs

Scale	Grand Mean γ_{00}	Between Class Variance σ_0^2	Within Class Variance σ_e^2	Total Variance $\sigma_T^2 = \sigma_0^2 + \sigma_e^2$	% of variance between classes %	% of variance within classes %	Intra-class correlation (ρ)
Post-test High School Knowledge	0.695 (0.029)	0.011* (0.005)	0.089 (0.008)	0.100	11.00	89.00	0.110*
Post-test Movie Knowledge	0.866 (0.023)	0.008* (0.003)	0.035 (0.003)	0.043	18.60	81.40	0.186*
Post-test Information Processing	0.773 (0.022)	0.008* (0.003)	0.032 (0.003)	0.040	20.00	80.00	0.200*
Knowledge of Databases	0.823 (0.020)	0.007* (0.003)	0.023 (0.002)	0.030	23.33	76.67	0.233*
Computer Liking	2.779 (0.042)	0.016 (0.011)	0.278 (0.024)	0.294	5.44	94.56	0.054
Computer Confidence	3.364 (0.030)	0.000 (0.000)	0.259 (0.021)	0.259	0.00	100.00	0.000

Note: (a) Statistically significant at $p<0.05$ by univariate two tailed tests are indicated by a *
(b) Sample size = 293

The between-class variance for many of the student background variables and some of the student outcome variables failed to reach significance when compared to their standard errors[6]. While the between-class variance of these variables has no statistical significance, it still may be of substantive interest. For example, Computer Experience (Figure 8.1, ρ=0.092, p=0.069) shows considerable between-school variance in the plot of its variance components suggesting that the class effects of this variable may still be of substantial interest even though it failed to reach statistical significance. In addition, the variance of variables such as Computer Experience, that are on the edge of statistical significance, may become of greater consequence as their impact is compounded by the direct and indirect relationships that exist between variables in the model.

[6] In marginal cases significance was confirmed by using MLn's log likelihood test (Woodhouse et al, 1995).

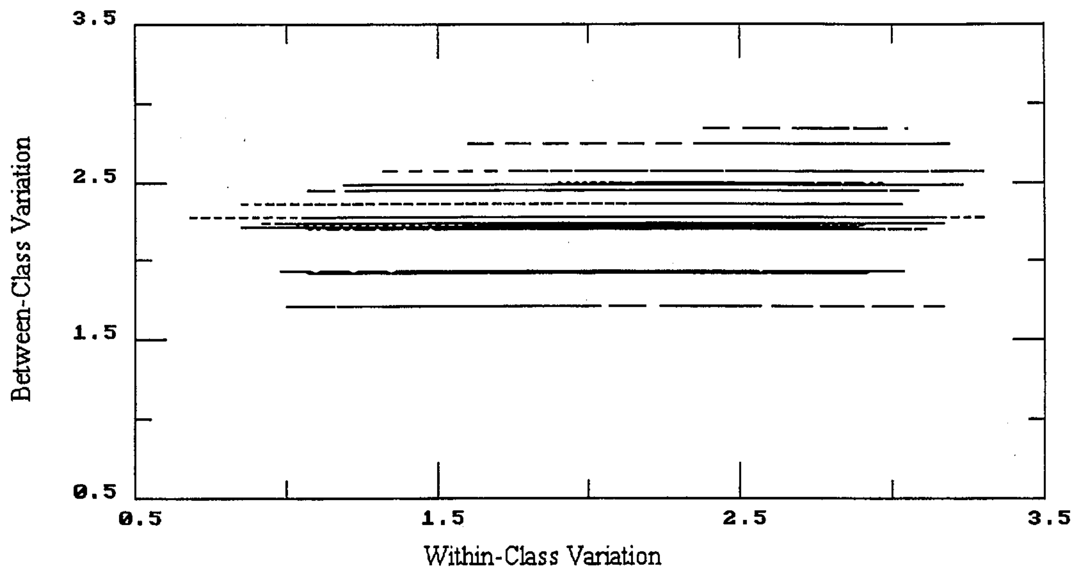

Figure 8.1 Variation in Computer Experience

Other variables, such as the Deep (approach to learning) and Adaptive (flexibility in learning) recorded zero between-class differences. It is unlikely that the between-class variation is exactly zero but rather it is too small to be estimated for the given sample (Goldstein, 1995). In these situations we can be certain that most of the variance in these variables is at the student level and is largely independent of classroom influences. It is still possible, however, that these variables may have non-random specifications at level-2 and should be included in the analysis on substantive grounds (Bryk & Raudenbush, 1992: 17).

Between-class differences may be expected in some variables and can be explained on substantive grounds. The between-class differences in Age result because some of the classes in the study contained Year 10 students working in Computing Studies. The between-class differences in Gender result from some of the schools in the study having complete, or near, single gender classrooms. Differences in Information Processing may be due to a number of factors that include past educational experiences and groupings of individual abilities. Differences in the post-test constructs may be due to pre-test abilities and classroom factors during the study. Other between class-differences may not be expected, for example, differences in Pre-test Knowledge of movies were not expected and are difficult to explain on substantive grounds.

Stage 2 of the Analysis: The Explanatory Multilevel Model

The relationships between the background, intermediate, and outcome constructs were investigated using simple MLn multilevel regression models (Goldstein, 1995) for each of the four outcome constructs. Using these models it was possible to investigate the proportion of variance in the response variables that was accounted for by the effects of the explanatory variables, and to take into account the sampling structure of the data. This also enabled the investigation of a number of cross-level influences in the models.

To fully describe each model the various constructs were treated as response variables (Y_{ij}) for student *i* in class *j* respectively. The student background variables and classroom variables that included Age (X_1), Gender (X_2), Computer Experience (X_3), Approach to Learning Variables: (Deep, Surface, Achieving) (X_4-X_6), Flexibility in Learning (Adaptive, Irresolute, Inflexible) (X_7-X_9), Personality (X_{10}), Pre-test Knowledge: (High School, Movies) (X_{11}-X_{12}), Pre-test Information Processing (X_{13}), Post-test Information Processing (X_{14}), and the classroom variables of Implementation (Z_1), Heuristic (Z_2), Teacher Engagement (Z_3), Hardware (Z_4), Software (Z_5), Direct Instruction (Z_6), Modelling (Z_7), Peer Interaction (Z_8), Class Size (Z_9), and Students on Task (Z_{10}) were entered as explanatory variables.

After Pang (1996: 197), the simple multilevel regression models can be represented by the following equations:

Level 1:
$$Y_{ij} = \beta_{0j} + \beta_{1j}(X_{1ij}) + \beta_{2j}(X_{2ij}) +....+ \beta_{Pj}(X_{Pij}) + \alpha_1(Z_{1j}) + \alpha_{2j}(Z_{2j}) +....+ \alpha_Q(Z_{Qj}) + e_{ij}$$

Level 2:
$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$

where it is assumed that $e_{ij} \sim \text{NID}(0, \sigma_e^2)$ and $\mu_{0j} \sim \text{NID}(0, \sigma_0^2)$. The two random terms ($e_{ij}$ and μ_{0j}) represent the sum of all influences on Y_{ij} other than those of the explanatory variables. γ_{00} is the average intercept across the classes. The intercept β_{0j} is the average change in outcome Y_{ij} for each unit of change in the explanatory variables (X_1-X_{14} and Z_1-Z_{10}). The regression coefficients β_{pj}, p=0,1,...P, and α_{qj}, q=0,1,...Q indicate how the response variable is distributed in class *j* as a function of both the measured student and class characteristics. In doing this, multilevel regression models estimate both the level-1 (e_{ij}) and level-2 (μ_{0j}) random variations as well as the student level (β_{pj}) and class level (α_{qj}) regression coefficients using iterative generalised least squares as compared to ordinary least squares regression that estimates the random variations and regression coefficients at the student level only.

In estimating all the models, the explanatory variables were entered one at a time for each response variable. Explanatory variables were entered in the order of their theoretical importance to minimise chance relationships occurring in the data. If the explanatory variable was found to be significant it was retained and the next explanatory variable was added. However, if the explanatory variable was not found to be significant it was discarded and the next explanatory variable was entered. Significance was determined by comparing the standardised regression coefficient to its standard error using a 2-tailed test. As such, significance is achieved if the coefficient is 1.96 times its standard error. In marginal cases significance is confirmed using the log likelihood ratio test (Woodhouse et al, 1995). The parameter estimates (βs, e_{ij}, μ_{0j})[7] for the solutions of the multilevel models under iterative generalised least squares estimation are found in Tables 8.3-8.5[8].

Fixed Effects in the Multilevel Model

The significant direct fixed effects of the full standardised model are shown in Figure 8.2. The effect sizes ranged from β=0.11 to β=0.79. The total variance explained for the various sub-models ranged from 2 percent to 67 percent. Each of the submodels will now be examined in turn with standardised regression coefficients used in the final form of the fitted models. The submodels will be considered by moving from left to right through the general model for analysis. Presage factors, including student background and intermediate variables and constructs, will be considered first followed by process factors, including level-2 classroom effects. Finally, product factors including student knowledge, information processing, and attitudes will be considered.

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[7] The student- and class-level standardised regression coefficients will now be discussed using the common symbol β.

[8] There were small variations from the descriptive statistics results reported in Chapter 6 in which the entire sample of 541 students was included. During the MLn analysis the sample consisted of the 293 students for which there was no missing data.

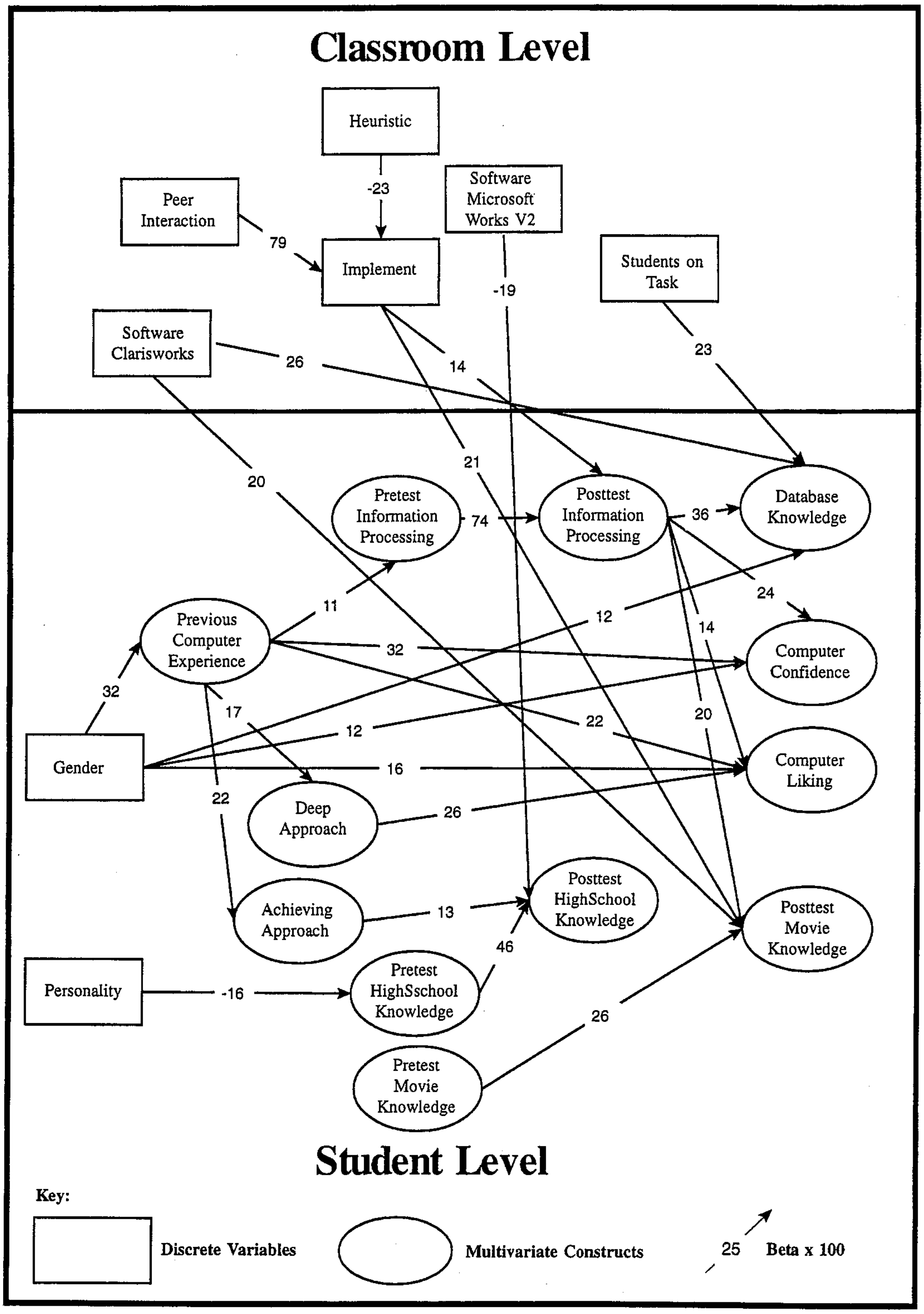

Figure 8.2 **Multilevel Path Model - Learning in the Classroom**

Presage Factors: Student Background Variables and Constructs

Results for the level-1 student background variables of Age, Gender, and Personality are presented in Table 8.5.

Age

The base model for Age recorded a grand mean of 176.60 months. The intra-class correlation coefficient was found to be 0.210 (21 percent of the variance of age was at the class level). The significance of the variance at the student- and class-levels was determined by comparing the parameter estimate to its standard error. The class-level variance was established as significant (σ_0^2=0.209, S.E.=0.083) as was the student-level variance (σ_e^2=0.787, S.E.=0.067). Age is a student background variable in the present study and consequently it was not possible for it to be affected by other variables. For this reason, no explanatory variables were added to the model. The Age variable was omitted from other submodels as it failed to form significant links with any of the other variables in the models.

Gender

The base model for Gender recorded a grand mean of 0.564 (unstandardised model) indicating that just over half of the students in the sample were males (A mean of 0.5 would have indicated that there was the same number of males as females.) The intra-class correlation coefficient in the standardised model was found to be 0.159, that is, almost 16 percent of the variance of Gender was at the class level which was established as significant (σ_0^2=0.039, S.E.=0.017) as was the student-level variance (σ_e^2=0.209, S.E.=0.018). Similar to Age, Gender is included as a student background variable and no explanatory variables were added to the model.

Personality

The base model for Personality recorded a grand mean of 0.763 (unstandardised model) on a scale from 0 (introverted) to 1 (extroverted). This indicated that students in the study tended to be extroverted. The intra-class correlation coefficient in the standardised model was found to be 0.043 indicating that 4.3 percent of the variance of Personality was at the class level which was not significant (σ_0^2=0.038, S.E.=0.031).

The student-level variance was significant (σ_e^2=0.837, S.E.=0.072). As Personality was a student background variable, no explanatory variables were added to the Personality model.

Table 8.5 Base Model for Student Background

Parameters (β) n=293 students		Student Background		
		Age	**Gender**	**Personality**
Base Model Fixed Part	Constant	-0.001	0.000	0.018
RandomPart	L-2	0.011	0.000	0.071
	L-1	0.983	0.996	0.926
	ρ	0.011	0.000	0.071

Student Intermediate Constructs

As well as the student background variables and constructs, Level-1 of the model also contains the student intermediate constructs of Approaches to Learning, Computer Experience, Pre-test Information Processing, and Pre-test Knowledge. The Flexibility in Learning constructs were omitted from the various submodels as they failed to form significant links with any of the other variables in the models.

Student intermediate constructs may be influenced by the student background variables, student background constructs and by other student intermediate constructs. Each of the student intermediate models will be considered in turn with the results for Approaches to Learning (Achieving, Deep, Surface) and Computer Experience presented in Table 8.6. and results for Pre-test Information Processing and Pre-test Knowledge presented in Table 8.7.

Approaches to Learning

Students approach learning with a preferred style. Biggs and Moore (1993) suggest that students prefer an achieving, deep, or surface approach to their learning.

Achieving

The base model for the achieving approach to learning recorded a grand mean of 3.41 (unstandardised model) indicating that students preferred an achieving approach to learning slightly more than half the time. The intra-class correlation coefficient in the standardised model was found to be 0.011 indicating that 1.1 percent of the variance of Achieving was at the class level which was not significant (σ_0^2=0.011, S.E.=0.025). The student-level variance was established as significant (σ_e^2=0.986, S.E.=0.084).

Table 8.6 Base and Final Fitted Standardised Model for Student Intermediate Constructs

Parameters (β) n=293 students		Student Intermediate Constructs			
		Achieving	Deep	Surface	Experience
Base Model Fixed Part	Constant	-0.001	0.000	0.000	0.018
RandomPart	L-2	0.011	0.000	0.002	0.071
	L-1	0.986	0.997	0.994	0.930
	ρ	0.011	0.000	0.002	0.071
Fitted Model Fixed Part	Constant	-0.001	0.000	0.000	0.011
	Student Background				
	Age	-	-	-	-
	Gender	-	-	-	0.318 (0.055)
	Personality			-	-
	Achieving	-	-	-	-
	Deep	-	-	-	-
	Surface	-	-	-	-
	Irresolute	-	-	-	-
	Inflexible	-	-	-	-
	Adaptive	-	-	-	-
	Experience	0.217 (0.057)	0.166 (0.058)	-	-
	pre-IP	-	-	-	-
RandomPart	L-2	0.018	0.000	-	0.033
	L-1	0.934	0.969	-	0.813
	ρ	0.019	0.000	-	0.039
	R^2	0.047	0.028	-	0.148

Explanatory variables were entered into the model and to avoid problems with colinearity associated with the correlation between Computer Experience and Gender, Computer Experience was entered into the model at the expense of Gender. This decision was based on the significant correlation between Computer Experience and Achieving, and the lack of a significant correlation between Gender and Achieving (Table 7.1).

Computer Experience was found to be significant in the final form of the fitted Achieving model (β=0.22) indicating that students with more computer experience were more likely to adopt an achieving approach to their learning.

Introducing this explanatory variable into the fixed part of the model reduced the total unexplained variation from 0.997 to 0.952, providing a R^2 measure of 0.047 (4.7 percent of the variance in Achieving was explained by the explanatory variable.) This is a small amount indicating that there are other factors, aside from Computer Experience, that are responsible for explaining the variance in Achieving.

Deep

The grand mean for the Deep approach to learning was 2.80 (unstandardised model) indicating that students prefer a deep approach to learning slightly less than half the time. The intra-class correlation coefficient in the standardised model was found to be 0.000 (0 percent). It is unlikely that the class level variance is exactly zero but rather it was too small to measure with the current sample size. The student-level variance was established as significant (σ_e^2=0.997, S.E.=0.082).

Similar to the previous model, to avoid problems with colinearity, Computer Experience was entered into the model at the expense of Gender. This decision was based on the correlation between Experience and Gender, and Experience and Deep, and the lack of correlation between Gender and Deep (Table 7.1). Computer Experience was found to be significant in the final form of the fitted Deep model (β=0.17) indicating that students with more computer experience were more likely to adopt a deep approach to learning.

Introducing this explanatory variable into fixed part of the model reduced the total unexplained variation from 0.997 to 0.969, providing a R^2 measure of 0.028 (2.8 percent of the variance in Deep was explained by Computer Experience). This is a small amount, however, it was not expected that a large proportion of the variance in these early sub-model variables would be explained by the explanatory variables in the model. Only two explanatory variables were entered, and only one was found to be significant (Computer Experience). This result should be interpreted that other variables, apart from Gender, Personality, and Computer Experience, are necessary to fully explain the variance in the Approach to Learning constructs.

Surface

The base model for the surface approach to learning recorded a grand mean of 3.373 (unstandardised model) indicating that students preferred a surface approach to learning slightly more than half the time. The intra-class correlation coefficient in the standardised model was found to be 0.002, that is, 0.2 percent of the variance in Surface was explained by class level variation which was not significant (σ_0^2=0.002, S.E.=0.023). The student-level variance was established as significant (σ_e^2=0.994, S.E.=0.085).

No explanatory variables were found to be significant in the final form of the fitted Surface model.

Computer Experience

As the Computer Experience construct is a composite of other scales it does not have a natural metric. It ranges from a potential minimum value of 0.5 to a potential maximum value of 3.2 with 1.85 at the mid-point of the scale. The base model for Computer Experience recorded a grand mean of 2.341 (unstandardised model) indicating that students came to the present study with some degree of general computer experience. The intra-class correlation coefficient in the standardised model was found to be 0.071 indicating that 7.1 percent of the variance in Computer Experience was at the class-level which was not significant (σ_0^2=0.071, S.E.=0.043). The student-level variance was established as significant (σ_e^2=0.930, S.E.=0.079).

The final fitted form of the Computer Experience model included Gender (β=0.32) as a significant explanatory variable indicating that males had more general computer experience than females. Introducing this explanatory variable into the fixed part of the model reduced the total unexplained variation from 1.000 to 0.852 indicating that the explanatory variables explained nearly 15 per cent of previously unexplained variance.

Pre-test Knowledge Constructs

The Student Intermediate constructs of Pre-test High School Knowledge and Pre-test Movie Knowledge will now be considered. The results for these constructs are presented in Table 8.7.

Table 8.7 Base and Final Fitted Standardised Model for Student Intermediate Constructs

Parameters (β) n=293 students		Student Background		
		Pre-test High School Knowledge	**Pre-test Movie Knowledge**	**Pre-test Information Processing**
Base Model Fixed Part	Constant	-0.004	-0.001	-0.010
RandomPart	L-2	0.043	0.142	0.218
	L-1	0.954	0.851	0.791
	ρ	0.043	0.143	0.218
Fitted Model Fixed Part	Constant	-0.003	-0.001	-0.014
	Student Background			
	Age	-	-	-
	Gender	-	-	-
	Personality	-0.156 (0.058)	-	-
	Achieving	-	-	-
	Deep	-	-	-
	Surface	-	0.151 (0.055)	-
	Irresolute	-	-	
	Inflexible	-	-	
	Adaptive	-	-	
	Experience	-	-	0.110 (0.54)
RandomPart	L-2	0.035	0.144	0.210
	L-1	0.931	0.828	0.781
	ρ	0.035	0.148	0.212
	R^2	0.031	0.021	0.018

Pre-test High School Knowledge

The Pre-test High School Knowledge construct was measured using a scale from 0 to 1. The base model for Pre-test High School Knowledge recorded a grand mean of 0.527 (unstandardised model) indicating that most students had some knowledge of the information in the high school database at the commencement of the study. The intra-class correlation coefficient in the standardised model was found to be 0.043, that is, 4.3 percent of the variance in Pre-test High School Knowledge was explained at the class level which was not significant (σ_0^2=0.043, S.E.=0.035). The student-level variance was established as significant (σ_e^2=0.95, S.E.=0.082).

The final fitted form of the Pre-test High School Knowledge model included one significant explanatory variable, Personality (β=-0.16), indicating that introverted students had more knowledge of the information in the high school database at the commencement of the study. Introducing the explanatory variable into fixed part of the model reduced the total unexplained variation from 0.997 to 0.966, providing a R^2 measure of 0.031 (the explanatory variable explained 3 percent of the previously unexplained variance).

Pre-test Movie Knowledge

The Pre-test Movie Knowledge construct was measured using a scale from 0 to 1. The base model for Pre-test Movie Knowledge recorded a grand mean of 0.646 (unstandardised model) indicating that students had more knowledge of the information in the movie database at the commencement of the study than they had of the information in the High School database. The intra-class correlation coefficient in the standardised model was found to be 0.143 indicating that 14.3 percent of the variance in Pre-test Movie Knowledge was explained by between-class variance which was significant (σ_0^2=0.142, S.E.=0.064) as was the student-level variance (σ_e^2=0.851, S.E.=0.073).

The final fitted form of the Pre-test Movie Knowledge model included one significant explanatory variable, Surface (β=0.15), indicating that students who preferred a surface approach to learning had more knowledge of the movie information in the database. Biggs and Moore (1993: 310) define a student's preferred approach to learning as the combination of a motive and a strategy. Students who prefer a surface approach are motivated by the desire to have fun and strategically they choose to do the minimum amount of work required (Biggs & Moore, 1993: 316). Such students may have more leisure time and watch more movies and hence be more familiar with the movies in the database. Introducing the explanatory variable into fixed part of the model reduced the total unexplained variation from 0.993 to 0.972, providing a R^2 measure of 0.021.

Pre-test Information Processing Construct

The information processing construct was intended to provide a measure of the procedural knowledge used by students as they solved problems using computerised databases. The pre-test results for this construct are presented in Table 8.7.

Pre-test Information Processing

Pre-test Information Processing was measured using a scale that ranged from 0 to 1. The base model for Pre-test Information Processing recorded a grand mean of 0.608 (unstandardised model) indicating that students had some knowledge of information processing at the start of the study. The intra-class correlation coefficient in the standardised model was found to be 0.218, that is, almost 22 percent of the variation in Pre-test Information Processing was due to between-class variation which was significant (σ_0^2=0.218, S.E.=0.086) as was the student-level variance (σ_e^2=0.791, S.E.=0.068).

The final fitted form of the Pre-test Information Processing model included one significant explanatory variable; Computer Experience (β=0.11) indicating that students who had more previous computer experience had greater information processing skills. There was also an indirect path from Gender to Pre-test Information Processing via Computer Experience (β=0.32 x 0.11= 0.04) indicating that males have more Computer Experience than females and hence could be expected to perform better at Information Processing Tasks. Although the effect of this path is small it may be of interest.

Introducing the explanatory variable into the fixed part of the model reduced the total unexplained variation from 1.009 to 0.991, providing a R^2 measure of 0.018. It was not expected that a large amount of the variance of the presage factors would be explained by explanatory variables and other variables, apart from those included in the model, are needed to explain the variance in Pre-test Information Processing.

Process Factors: Classroom Effects

Classroom observational data were collected throughout the study. The Classroom Observation Instrument was used to record observations for 22 of the classes in the study over a series of five lessons. These observations collected data on teaching methods and student behaviour as teachers implemented the database course in their classrooms. An explanatory model was developed to determine how the various classroom variables included in the study influenced the implementation of the database course. These level-2 fixed effects are discussed below and presented in Table 8.8.

Table 8.8 Base and Final Fitted Standardised Model for Classroom Variables

Parameters (β) n=293 students		Classroom Level Implement		
Base Model Fixed Part	Constant	-0.162		
RandomPart	L-2	1.026		
	L-1	0.000		
	ρ	1.000		
Fitted Model Fixed Part	Constant	-0.024		
	Classroom Variables		**School Variables**	
	Heuristic	-0.234 (0.097	school 1	-
	W/Heuristic	-	school 2	-
	student/comp	-	school 3	-
	Software (apwk)	-	school 4	-
	software (clwk)	-	school 5	-
	software (mw2)	-	school 6	-
	software (mw3)	-	school 7	-
	direct instruction	-	school 8	-
	modelling	-	school 9	-
	peer interact	0.790 (0.093)	school 10	-
	class size	-	school 11	-
	teacher engage.	-		
	students on task	-		
RandomPart	L-2	0.360		
	L-1	0.000		
	ρ	1.000		
	R^2	0.649		

Implement

The Implement variable is a measure of how successful the individual teachers were at implementing the database course in their classrooms and was measured using a scale ranging from 1 to 5. The base model for Implement recorded a grand mean of 3.2 (unstandardised model) indicating that teachers were reasonably successful at implementing the course in their classrooms. As Implement is a level 2 variable, all variation in Implement was due to between class differences. The class-level variance was significant (σ_0^2=1.026, S.E.=0.317).

The final fitted form of the Implement model included two significant explanatory variables from the class level: Peer Interaction (β=0.79) indicating that teachers were more successful at implementing the database course in classrooms in which students worked with their peers and interacted in cooperative problem solving groups, and Heuristic (β=-0.23) indicating that those teachers who were working using the heuristic as part of the database course were not as successful at implementing the database course as those teachers who were not using the heuristic. There were no significant between-school differences as none of the school dummy variables entered during the analysis was found to be significant. Introducing the explanatory variables into fixed part of the model reduced the total unexplained variation from 1.026 to 0.360, indicating that the explanatory variables explained nearly 65 percent of the previously unexplained variance.

Student Outcome Constructs

Post-test Information Processing, Post-test Knowledge (High School, Movies), Post-test Databases Knowledge, and Student Attitudes to Computers (Confidence, Liking) make up the student outcome constructs in the present study. Each of the models for these constructs will be discussed in turn and results are presented in Tables 8.9 and 8.10. All of the student outcome constructs were measured on a scale that ranged from 0 to 1.

Post-test Information Processing

The base model for Post-test Information Processing recorded a grand mean of 0.773 (unstandardised model) indicating that, on average, students had increased their information processing ability from 0.608 in the pre-test. The intra-class correlation coefficient in the standardised model was found to be 0.207 indicating that almost 21 percent of the variance in Post-test Information Processing was due to between class differences which was significant (σ_0^2=0.207, S.E.=0.083) as was the student-level variance (σ_e^2=0.793, S.E.=0.068).

The final fitted form of the Post-test Information Processing model included one significant explanatory variable from the student level: Pre-test Information Processing (β=0.74). This very large coefficient indicates that students with more information processing knowledge at the commencement of the study had more knowledge of information processing at the conclusion of the study. There was also one significant explanatory variable from the classroom level, Implement (β=0.14), indicating that

Table 8.9 Base and Final Fitted Standardised Model for Information Processing and Knowledge Outcomes

Parameters (β) n=293 students		Outcome Variables			
		Post-test Information Processing	**Post-test HighSchool Knowledge** n=293	**Post-test HighSchool Knowledge** n=251	**Post-test Movie Knowledge**
Base Model Fixed Part		-0.019	0.008	0.008	-0.040
RandomPart	L-2	0.207	0.112	0.112	0.218
	L-1	0.793	0.873	0.873	0.773
	ρ	0.207	0.112	0.112	0.220
Fitted Model Fixed Part	Constant	0.000	0.022	0.094	0.004
	Student Background				
	Age	-	-	-	-
	Gender	-	-	-	-
	Personality	-	-	-	-
	Achieving	-	0.131 (0.048)	0.133 (0.054)	-
	Deep	-	-	-	-
	Surface	-	-	-	-
	Irresolute	-	-	-	-
	Inflexible	-	-	-	-
	Adaptive	-	-	-	-
	Experience	-	-	-	-
	Pre-test - IP	0.744 (0.036)	-	-	-
	Pre-test - HS	-	0.459 (0.049)	0.441 (0.053)	-
	Pre-test - Movie	-	-	-	0.260 (0.052)
	Student Outcomes				
	Post-IP	-	-	-	0.204 (0.054)
	Classroom Variables				
	Implementation	0.141 (0.036)	-	-	0.210 (0.083)
	Heuristic	-	-	-	-
	student/comp	-	-	-	-
	Software (apwk)	-	-	-	-
	Software (clwk)	-	-	-	0.202 (0.084)
	Software (mw2)	-	-0.192 (0.077)	-0.244 (0.063)	-
	Software (mw3)	-	-	-	-
	Direct instruct...	-	-	-	-
	Modelling	-	-	-	-
	Peer interact	-	-	-	-
	Class size	-	-	-	-
	Students on task	-	-	-	-
	School Variables				
	School 6	-	-0.224 (0.071)	-	-
Random Part	L-2	0.000	0.036	0.030	0.088
	L-1	0.336	0.646	0.672	0.655
	ρ	0.000	0.053	0.043	0.118
	R^2	0.664	0.303	0.283	0.247

students who were in classes where teachers were more successful in implementing the database course were better at information processing at the conclusion of the study. Introducing the explanatory variables into fixed part of the model reduced the total unexplained variation from 1.000 to 0.336 indicating the explanatory variables explained 66.4 percent of the previously unexplained variance.

Post-test High School Knowledge

The base model for Post-test High School Knowledge recorded a grand mean of 0.695 (unstandardised model). This represents a significant increase in knowledge of the information in the High School database from the pre-test mean of 0.527. The intra-class correlation coefficient in the standardised model was found to be 0.112, that is, 11.2 percent of the variance in Post-test Knowledge-High School was due to between class differences which was significant (σ_0^2=0.112, S.E.=0.055) as was the student-level variance (σ_e^2=0.873, S.E.=0.075).

The final fitted form of the Post-test High School Knowledge model included two significant explanatory variables from the student level: Pre-test High School Knowledge (β=0.46) indicating that students who scored higher on Pre-test High School Knowledge scored higher on Post-test High School Knowledge, and Achieving (β=0.13) indicating that students who preferred an achieving approach to their learning scored higher on Post-test High School Knowledge. There was also one significant explanatory variable from the classroom level: Software-Microsoft Works 2 (β=-0.19) indicating that students who used Microsoft Works 2 performed significantly worse on Post-test High School Knowledge than students using other software packages. One possible explanation for this is that the Microsoft Works 2 database is command driven rather than menu driven. Students who used this software package may have experienced difficulty with the syntax of the commands when performing database operations, especially queries, and this prevented them from interacting with the database data as freely as students using other software packages. Consequently, their access to the information in the database was restricted. A similar effect was noted in the other post-test knowledge measure (movies) however it failed to reach significance.

When the schools were entered as dummy variables in the regression equation, School 6 was the only school found to be significantly different on Post-test High School

Knowledge (β=-0.22). School 6 contributed two classes to the study and these classes were taught by the same teacher. When the non-significant variables were removed from the regression equation, the significant coefficient for School 6 on Post-test High School Knowledge indicated that students in this school performed significantly worse than students in the other schools in post-test high school knowledge. This significant difference may be due to the small standard error of school 6 on the Post-test High School scale (0.046) as compared to other schools. This small standard error was due to a smaller class variation on the post-test measure as compared to other schools, combining with larger class sizes for school 6 (this led to it having the second largest school size in the sample). The small standard error for school 6 may have led to it being identified as being significantly different when in fact School 2 recorded a school mean on the Post-test High School measure that was lower than school 6 but, because School 2 also recorded a larger standard error on the scale (0.072), it was not identified as being significantly different.

It should be noted that the teacher in School 6 found many of the teaching methods in the course new to her. Although she was very enthusiastic about taking part in the study, she took some time to become accustomed to the methods employed in teaching the course. This was noted as the researcher visited her classroom and the initial scores she received on the implement scale reflected this. Additional time was spent with the teacher to help her come to terms with the methods of teaching the course and the way in which the course ran. She steadily improved the way the course was implemented in her classroom and by the time the students studied the movie database there was no significant difference between her classes and the rest of the classes in the study.

Because of the significant difference of School 6 on Post-test High School Knowledge, it was decided to remove school 6 from the sample and perform the analysis again. This reduced the sample size to 251 students. The regression coefficients in the second analysis differed in magnitude but not in direction and no new significant explanatory variables were added to the equation. The regression coefficients for the second analysis are displayed along with the regression coefficients for the first analysis in Table 8.9.

Introducing the explanatory variables into fixed part of the first model[9] reduced the total unexplained variation from 0.985 to 0.682 indicating the explanatory variables

[9] The first model included all schools and all 293 students.

explained 30.3 percent of the previously unexplained variance. Introducing the explanatory variables into fixed part of the second model[10] reduced the total unexplained variation from 0.985 to 0.702 indicating that the explanatory variables explained 28.3 percent of the previously unexplained variance.

Post-test Movie Knowledge

The Post-test Movie Knowledge construct was measured using a scale that ranged from 0 to 1. The base model for Post-test Movie Knowledge recorded a grand mean of 0.866 (unstandardised model) indicating that students had significantly increased their knowledge of movies from a pre-test mean of 0.646. The intra-class correlation coefficient in the standardised model was found to be 0.220, that is, 22 percent of the variation in Post-test Movie Knowledge was due to between class differences which was significant (σ_0^2=0.218, S.E.=0.086) as was the student-level variance (σ_e^2=0.773, S.E.=0.066).

The final fitted form of the Post-test Movie Knowledge model included two significant explanatory variables from the student level: Pre-test Movie Knowledge (β=0.26) indicating that students who scored higher on Pre-test Movie Knowledge scored higher on Post-test Movie Knowledge, and Post-test Information Processing (β=0.20) indicating that students who were better at Information Processing scored higher on Post-test Movie Knowledge. There were also two significant explanatory variables from the classroom level: Implement (β=0.21) indicating that students who were in classes in which the teachers were more successful in implementing the database course were able to acquire more knowledge about movies, and Software-Clarisworks (β=0.20) indicating that students who were using Clarisworks software scored higher on Post-test Movie Knowledge than those students using other software programs. Introducing the explanatory variables into fixed part of the model reduced the total unexplained variation from 0.991 to 0.743 indicating that the explanatory variables explained nearly 25 percent of the previously unexplained variance.

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[10] The second model had school 6 removed from the data set and contained 251 students.

Post-test Database Knowledge

The results for the Post-test Database Knowledge model are found in Table 8.10. The Post-test Knowledge about Databases construct was measured using a scale that ranged from 0 to 1 and the base model for the construct recorded a grand mean of 0.866 (unstandardised model). The intra-class correlation coefficient in the standardised model was found to be 0.238 indicating that nearly 24 percent of the variance in Post-test Knowledge about Databases was due to between class differences which was significant (σ_0^2=0.242, S.E.=0.094) as was the student-level variance (σ_e^2=0.779, S.E.=0.067).

The final fitted form of the Post-test Database Knowledge model included two significant explanatory variables from the student level: Gender (β=0.12) indicating that males scored higher on Post-test Database Knowledge than females, and Post-test Information Processing (β=0.36) indicating that students who were better at Information Processing scored higher on Post-test Database Knowledge. There were also two significant explanatory variables from the classroom level: Students on Task (β=0.23) indicating that students who were in classes in which the students stayed on task longer were able to acquire more knowledge about databases, and Software-Clarisworks (β=0.26) indicating that students who were using Clarisworks software scored higher on Post-test Database Knowledge than those students on other software packages. One possible explanation for this is that Clarisworks is a menu driven database, and anecdotal evidence suggests that students found it much easier to use than the command driven databases used in some of the classrooms. Also the procedure for querying Clarisworks databases was much more straightforward and easier to use than the other database programs.

Introducing the explanatory variables into fixed part of the model reduced the total unexplained variation from 1.021 to 0.696 indicating that the explanatory variables explained 32.5 percent of the previously unexplained variance[11].

[11] As there was no pre-test for Database Knowledge it was expected that the explanatory variables would explain less of the variance of this construct.

Table 8.10 **Base and Final Fitted Standardised Model for Knowledge and Attitude Outcomes**

Parameters (β) n=293 students		Outcome Variables			
		Post-test Database Knowledge	**Computer Confidence**	**Computer Liking** n=293	**Computer Liking** n=264
Base Model Fixed Part		-0.038	0.001	-0.008	0.035
RandomPart	L-2	0.242	0.002	0.057	0.040
	L-1	0.779	0.995	0.941	0.991
	ρ	0.238	0.002	0.057	0.039
Fitted Model Fixed Part	Constant	0.001	0.000	-0.012	0.036
	Student Background				
	Age	-	-	-	-
	Gender	0.119 (0.084)	0.121 (0.055)	0.159 (0.057)	0.156 (0.061)
	Personality	-	-	-	-
	Achieving	-	-	-	-
	Deep	-	-	0.257 (0.052)	0.259 (0.056)
	Surface	-	-	-	-
	Irresolute	-	-	-	-
	Inflexible	-	-	-	-
	Adaptive	-	-	-	-
	Experience	-	0.322 (0.056)	0.215 (0.055)	0.206 (0.058)
	Pre-test - IP	-	-	-	-
	Pre-test - HS	-	-	-	-
	Pre-test - Movie	-	-	-	-
	Student Outcomes				
	Post-IP	0.362 (0.051)	0.241 (0.056)	0.159 (0.054)	0.154 (0.058)
	Classroom Variables				
	Implementation	-	-	-	-
	Heuristic	-	-	-	-
	Student/comp	-	-	-	-
	Software (apwk)	-		-	-
	Software (clwk)	0.262 (0.051)	-	-	-
	Software (mw2)	-	-	-	-
	Software (mw3)	-	-	-	-
	Direct instruct...	-	-	-	-
	Modelling	-	-	-	-
	Peer interact	-	-	-	-
	Class size	-	-	-	-
	Students on task	0.232(0.053)	-	-	-
	School Variables				
	School 8	-	-	-0.135 (0.065)	-
Random Part	L-2	0.004	0.000	0.030	0.028
	L-1	0.692	0.786	0.739	0.787
	ρ	0.006	0.000	0.039	0.034
	R^2	0.325	0.210	0.228	0.184

Student Attitudes to Computers

Students attitudes to computers were determined using the Computer Liking and Computer Confidence constructs. Both of these constructs were measured using scales that ranged from 1 to 4 and their results are presented in Table 8.10.

Computer Confidence

The base model for Computer Confidence recorded a grand mean of 3.364 (unstandardised model) indicating that students were confident in using computers. The intra-class correlation coefficient for the standardised model was found to be 0.001 indicating that one percent of the variation in Computer Confidence is due to between class differences which was not significant (σ_0^2=0.002, S.E.=0.022). The student-level variance was established as significant (σ_e^2=0.995, S.E.=0.085).

The final fitted form of the Computer Confidence model included three significant explanatory variables from the student level: The first two of these variables were Gender (β=0.12) indicating that males were more confident using computers than females, and Computer Experience (β=0.32) indicating that students with more computing experience were more confident using computers. The path from Gender to Computer Confidence was reinforced by an indirect path between these two variables via Computer Experience (β=0.32x0.32=0.10). This gives an indication of one possible reason for the gender differences in computer confidence. Males have more computer experience, which in turn leads to them having greater computer confidence. The third significant explanatory variable was Post-test Information Processing (β=0.24) indicating that students who were better at information processing were more confident in using a computer. Introducing the explanatory variables into fixed part of the model reduced the total unexplained variation from 0.997 to 0.786 indicating the explanatory variables explained 21 percent of the previously unexplained variance.

Computer Liking

The base model for Computer Liking recorded a grand mean of 2.779 (unstandardised model) indicating that students like using computers. The intra-class correlation coefficient for the standardised model was found to be 0.057, that is, nearly six percent of the variance in Computer Liking was due to between class differences which was not significant (σ_0^2=0.057, S.E.=0.039). The student-level variance was established as significant (σ_e^2=0.941, S.E.=0.081).

The final fitted form of the Computer Liking model included four significant explanatory variables from the student level: Gender (β=0.16) indicating that males like using computers more than females, Computer Experience (β=0.22) indicating that students with more computing experience like using computers more, Post-test Information Processing (β=0.16) indicating that students who were better at information processing liked using computers more, and Deep (β=0.26) indicating that students who prefer a deep approach to their learning like using computers more.

There was also an interesting indirect path in the model from Gender to Computer Liking via Experience (β=0.32x0.26=0.07) indicating that males have more computer experience and hence like using computers more. This indirect path is small compared to the significant direct paths, however, it does provide a useful insight that complements the larger direct paths.

When the schools were entered as dummy variables in the regression equation, School 8 was found to be significantly different on Computer Liking (β= -0.14). This school contributed two classes, taught by different teachers, to the study. The significant difference on Computer Liking indicated that students in this school did not like computers as much as those students in other schools. It is hard to give a definite explanation for this result as there are many factors that may affect how much students like working with computers. Although this school reported low levels of Computer Liking it was not the lowest on the Computer Liking scale. Due to the small variation in Liking at the school, it did record a small standard error for Computer Liking compared to the schools near it in the distribution. This may have made it statistically different to the other schools in the sample even though it may have not been that far removed from its neighbouring schools. It should be acknowledged that students in this school were forced to move into temporary classrooms just before the commencement of the study owing to a school fire. The arrangements in this temporary accommodation may also have been a factor in the difference in this school compared to the other schools.

It was decided to remove School 8 from the sample and perform the analysis again. In the second analysis the sample size was reduced to 264 students and the regression coefficients differed slightly in magnitude but not in direction. No new significant explanatory variables were added to the equation. The regression coefficients for the second analysis for this outcome are displayed along with the first analysis in Table 8.10. Introducing the explanatory variables into the fixed part of the first model[12] reduced the total unexplained variation from 0.998 to 0.769 indicating that the explanatory variables explained nearly 23 percent of the previously unexplained variance. Introducing the explanatory variables into fixed part of the second model[13] reduced the total unexplained variation from 0.998 to 0.814 indicating that the explanatory variables explained 18.4 percent of the previously unexplained variance.

Random Effects in the Model

Having discussed the significant fixed effects between student and classroom variables in the model, the discussion now turns to the random effects found to be significant in the multilevel model.

The random part of the model concerns the between-class variation at level-2 and between student within class variation at level-1. The variance components model established significant between class differences in the base model. These between class differences were significant in the case of Age (ρ= 0.320), Gender (ρ=0.157), Pre-test Information Processing (ρ=0.200), Pre-test Movie Knowledge (ρ=0.103), Post-test High School Knowledge (ρ=0.110), Post-test Movie Knowledge (ρ=0.186), Post-test Information Processing (ρ=0.200), and Knowledge of Databases (ρ=0.233).

The addition of non-random explanatory variables to the model may account for some of these between class differences. The addition of explanatory variables to the random part of the model may provide further information as to the differing effects that the explanatory variables have between classes. All of the variables in the model were tested as response variables for significant level-2 random effects. Only the Implementation variable was found to have a significant level-2 random effect as shown in Table 8.11.

[12] The first model included all schools and all 293 students.

In the Implementation model, the non-significant random estimate for the intercept term indicates that there was no significant difference between classrooms in Implementation of the database course once variation in peer interaction was allowed for. The significant positive gradient term PI/PI (β=0.209) indicates that as the level of peer interaction increases in the classroom, so did the level of implementation of the database course.

Table 8.11 Fixed and Random Effects in the Model

Parameters (β) n=293 students		Outcome Variable Implement
Fitted Model Fixed Part	Constant **Classroom Variables** heuristic peer interact	0.289 (0.014) -0.389 (0.018) 0.799 (0.106)
Random Part	L-2 PI/PI	 0.209 (0.065)
	L-1 R^2	0.000 (0.000) 0.408

Stage 3 of the Analysis: The Multivariate-Multilevel Model

The model used to explain relationships between variables in the computer classroom is illustrated in Figure 8.2. In this model there are five outcome variables: Post-test Information Processing, Post-test Database Knowledge, Post-test Movie Knowledge, Computer Confidence, and Computer Liking. The previous stages of the analysis have been primarily concerned with relationships between explanatory variables and these outcome (response) variables and across-level effects. We now turn our attention to determining if significant relationships exist between these outcome variables. It has been argued on theoretical grounds that Post-test Information Processing should precede the other four outcome variables (see Chapter 5). However, the relationship between the remaining four outcome variables is less clear. One way to investigate the relationship between these four variables is to use a multivariate-multilevel model. This type of model makes it possible to simultaneously model several response variables as

[13] The second model had School 6 removed from the data set and contained 264 students.

functions of explanatory variables (Goldstein, 1995). Within this model, multiple observations are considered to be within cases (students), who are within classes.

To define a multivariate model and the multilevel structure of the data, the students become the level-2 units and the 'within student' measurements of different outcomes are at level-1. The explanatory variables are a set of dummy variables that indicate which response variables are present. Additional response variables are defined by multiplying the response variables by individual student explanatory variables. As outlined in Smith (1996: 229), the variable (Y_{tij}) is the response variable t for student i, in class j, and is identified by a dummy variable (D_{tij}) such that $D_{tij} = 1$ when $t = 1$ otherwise $D_{tij} = 0$. To define a model that has k explanatory variables (X_{ijk}), the X_{ijk} and D_{tij} are used to form interaction terms ($X_{ijk} \times D_{ijk}$) such that the interaction terms have valid values equal to the observed values of X_{ijk} when $D_{tij}=1$, and the interaction term ($X_{ijk} \times D_{ijk}$)=0 when $D_{tij}=0$.

$$Y_{ij} = \beta_{0j}(D_{0ij}) + \beta_{0j}D_{0ij}(X_{0ij}) + \beta_{1j}(D_{1ij}) + \beta_{1j}D_{1ij}(X_{1ij}) + \ldots + \beta_{Pj}(D_{Pij}) + \beta_{Pj}D_{Pij}(X_{Pij}) + e_{ij}$$
$$\text{var}(e_{ij}) = \text{var}(e_j)$$

There is no level-1 variation specified because level-1 exists solely to define the multivariate structure. The level-2 variances and covariances are the residual between-student variances.

The models that the multivariate-multilevel procedure can be used to define include situations where:

- one response variable can influence other response variables, for example Y_{1ij} influences Y_{2ij}
- there are reciprocal relationships between response variables, that is where Y_{1ij} influences Y_{2ij} and vice versa.

The multivariate-multilevel procedure thus allows investigation of relationships between outcome variables by considering each in turn as a response variable with the other outcome variables as explanatory variables. It is for this reason that the multivariate-multilevel model is used in the current analysis.

Level-1 in the multivariate-multilevel model in the current analysis is a vector of unity referencing all records that are grouped within the multivariate responses of level-2 units (the students referenced by their student numbers). Level-3 units are the 22 classrooms in the sample referenced by their classroom numbers. The multivariate-multilevel model showing all possible paths is illustrated in Figure 8.3.

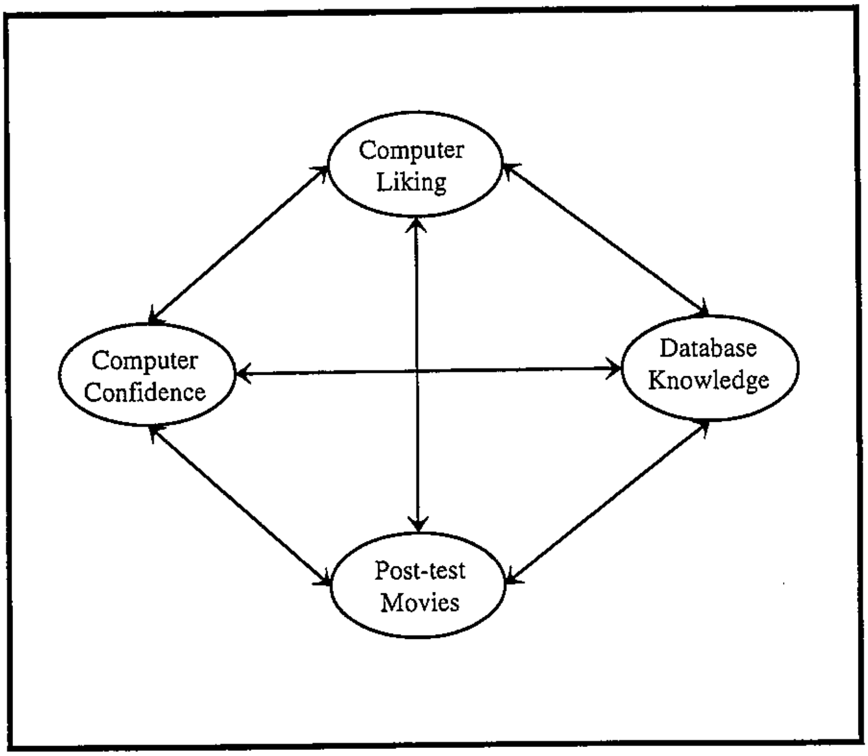

Figure 8.3 All Possible Paths in the Multivariate-multilevel Model

Results from the fitted multivariate-multilevel model are shown in Table 8.12 and summarised in Figure 8.4.

Estimation of such models can be very slow to converge because of the large number of iterations that are necessary and problems with negative definite matrix elements. Convergence can be achieved more efficiently when the intercept terms are removed from the fixed part using the FPAR command (Rasbash & Woodhouse, 1995). This removes the intercept terms from the fixed part of the model but leaves them in the random part. After Smith (1996: 230), the variables were standardised before estimation commenced, and it was expected that the regression lines would pass through the origins. This is appropriate as it is expected that the intercept terms in the fixed part of a standardised model will be zero.

Table 8.12 Student Outcomes: Fixed Part of Fitted Multivariate-multilevel Model, Standardised Solution (effective n= 293)

Fixed Part	Response Variables	Estimate	Std Error
Explanatory Variables			
Computer Confidence	Database Knowledge	0.178	0.053
Computer Confidence	Computer Liking	0.241	0.056
Computer Liking	Database Knowledge	0.148	0.053
Post-test Movies	Database Knowledge	0.220	0.055

Notes:

a. The effective sample size was 293 students, however the multivariate data set consists of 1172 records, four times this figure. This represents one record for each observation for each of the 293 students.

b. Intercepts of the multivariate response variable had near zero coefficients in the fixed part of the model, indicating that the summary regression line passed close to the origin. This is expected in a standardised model. To avoid problems with convergence during the estimation, intercept terms were removed from the fixed part of the model but retained in the random part of the model.

c. Standard errors provide a general indicator of the significance of parameters in the fixed part of the model. Significance was then confirmed using the likelihood ratio test (Woodhouse et al., 1995)

Fixed Effects in the Model

The original model tested was endogenous and non-recursive. The general form of the fitted model was recursive. The 'ultimate' response variable was Database Knowledge with three of the four significant paths leading to it. All were found to be positive. The other path was from Computer Confidence to Computer Liking (β=0.241) which indicates that students who were more confident using computers like using them more. The path from Computer Liking to Database Knowledge (β=0.148) indicates that students who like computers had more knowledge of databases and were better at using them.

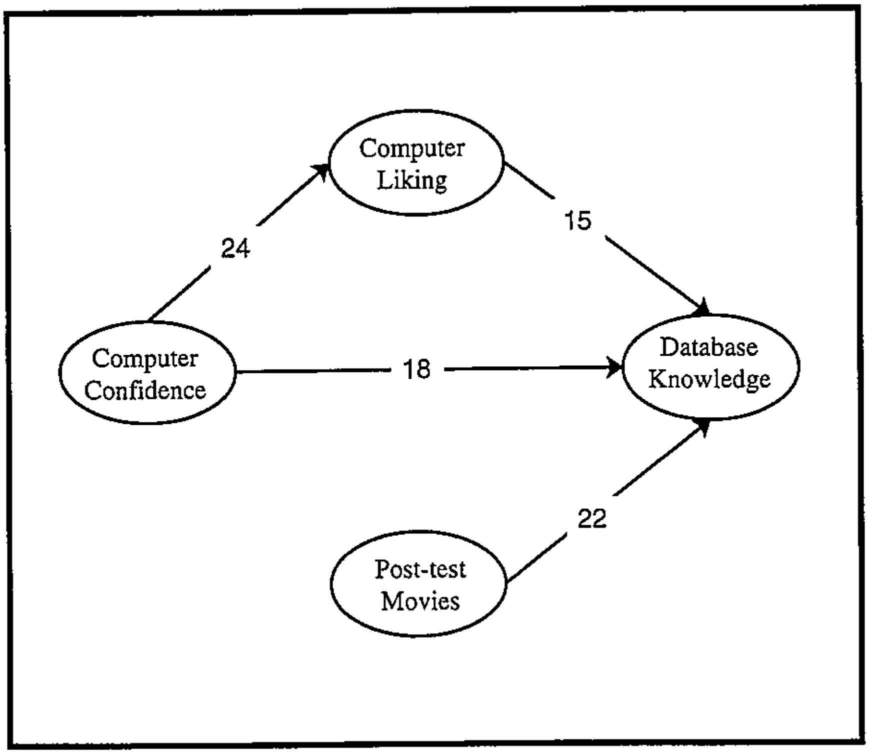

Figure 8.4 Multivariate-multilevel Model of Outcomes (Standardised Solution)

A similar effect is shown in the other computer attitude measure with a path from Computer Confidence to Database Knowledge (β=0.178) that indicates that students who are more confident in using computers had more knowledge of databases and were better at using them. The final significant path in the multivariate-multilevel model from Post-test Movies to Database Knowledge (β=0.220) indicated that those students who performed at a higher level on the Post-test Movie Knowledge scale had more knowledge of databases and were successful at using them. The total variance explained by this model was approximately 22 percent[14].

[14] Total variance explained in the MLn model was calculated to be 0.221, calculated as the difference between the total variance in the variance components base model and the total variance in the fitted model.

Random Effects in the Model

Having discussed the significant fixed effects between variables in the multivariate-multilevel outcomes model, the discussion will now turn to significant random effects in the model. The modelling of variances and covariances in the random part of the model was kept to a minimum due to the small sample size (Bryk & Rashbash, 1992).

The random part of the multivariate-multilevel model concerns the between class-variation at level-3 and between-student variation at level-2. The variance components model summarised in Table 8.4 established the extent of class-level effects for the outcome constructs that act as the response and explanatory variables in the multivariate-multilevel model. Between class differences were significant in the case of Post-test Knowledge-Movies (ρ=0.186), and Knowledge of Databases (ρ=0.233), and not significant in the case of the attitude constructs, Computer Liking (ρ=0.054),and Computer Confidence (ρ=0.000). It is possible that the addition of non-random explanatory variables may account for some of the between class differences. In the case of variables that have high intra-class correlations, it is also possible that the random part of the model can be used to see if the effects of the explanatory variables differ between classes (Breen, 1995).

Level-2 Random Effects

Results from the random part of the multivariate-multilevel model are presented in Table 8.13. Level-2 random variation in the multivariate-multilevel model is random variation at the student-level, that is, variation in student outcomes about the average level of outcomes for students in that class. All of the four random coefficients found to be significant at Level-2 were associated with the constant terms in the structural equations for the multivariate response variables. These terms represent the deviation of individual student's actual scores from those predicted from the regression line for their class (Woodhouse et al, 1995, Smith, 1996: 243). Since no other random variables were found to be significant at Level-2 it can be concluded that most of the variation in student outcomes can be explained from within-class and between-student differences.

Level-3 Random Effects

Level-3 random variation is concerned with the effect of explanatory variables on classrooms around the average effect sizes given in the fixed part of the model. Two terms were found to be significant at Level-3. These were the intercept term in the Knowledge of Databases structural equation, and the intercept term in the Post-test Movies structural equation. Both of these variables were identified as having level-3 variance in the variance components model (level-2 variance in the variance components model).

Table 8.13 Student Outcomes: Random Part of the Fitted MLn Multivariate-Multilevel Model, Standardised Solution. (effective n = 293[a])

Random Part	Estimates[d]	Standard Error
Level-3		
Dat_Con/Dat-Con[b]	0.152	0.064
PstM_Con/PstM_Con	0.226	0.088
Level-2		
Dat_Con/Dat-Con[c]	0.728	0.062
Conf_Con/Conf_Con	0.989	0.084
Like_Con/Like_Con	0.884	0.076
PstM_Con/PstM_Con	0.772	0.066
Total Variance Explained[e]		22.12%

Abbreviation	Variable Name
Dat	Database Knowledge
PstM	Post-test Movie
Conf	Computer Confidence
Like	Computer Liking

Notes:

a. The effective sample size was 293, however the multivariate data structure is 4 times this figure.

b. Var_Con/Var_Con is the random coefficient associated with the intercept for the relevant variable. At level-3 in a multivariate-multilevel model this term represents class-level random variation about the origin of the variable.

c. Var_Con/Var_Con is the random coefficient associated with the intercept for the relevant variable. At level-2 in a multivariate-multilevel model this term represents individual student outcomes about the summary model for each school for the variable.

d. These random parameter estimates were those that are judged significant by comparison with their standard errors and confirmed by the likelihood ratio test (Woodhouse et al, 1995).

e. Calculated as the percentage difference between total variance explained in the variance components base model and total variance explained in the final form of the fitted model.

Level-3 variation in the intercept term in Knowledge of Databases (σ^2=0.152, S.E.=0.064) indicates that between class variations in student knowledge of databases has not been fully explained by the variables that have been included in the fixed part of the equation. That is, there are still other variables, apart from those included in the fixed part of the model, that need to be included to fully explain the level-3 variation in student knowledge of databases.

Level-3 variation in the intercept term in Post-test Knowledge-Movies (σ^2=0.226, S.E.=0.088) can be interpreted in a similar way as the previous random variable. The between class variations in student post-test knowledge of movies has not been fully explained by the variables that have been included in the fixed part of the equation.

The random effects in the multivariate-multilevel model can offer additional insight into structural relationships within a model. In the present case, the random effects serve to highlight the presence of between-student and between-class variation in the model and also serve notice that variation still exists that has not been explained by the variables in the fixed part of the model. Because of the absence of variables in the random part of the model that were not intercept terms, the interpretive power of the model has not been greatly enhanced. One reason for the absence of non-intercept terms in the random part of the model may be the small sample of only 293 students at level-2 and 21 classes at level-3. A larger sample that contained a greater number of units at level-3 may have improved the interpretive power of the random part of the model by enabling more accurate estimates of variation between higher level units (Goldstein, 1995).

Summary

This chapter contains an analysis in which consideration has been given to the factors that interact to form a dynamic learning environment in the computer classroom. Multilevel techniques were employed to analyse the student and classroom data in three stages. Stage one consisted of a variance components analysis to determine the extent of the multilevel structure in the data. Eight of the variables showed significant between class variance making the use of multilevel techniques essential so that more precise statistical and substantive conclusions could be drawn from the analysis.

Stage two of the analysis consisted of the development of a number of multilevel models. These models are summarised graphically in Figure 8.2 and show how the various student background variables, student intermediate variables, classroom context variables, and student outcome variables interact to form the dynamic classroom learning environment when students work with computerised databases.

The third stage of the analysis consisted of the development of a multivariate-multilevel model to test relationships between the outcome measures. The significant relationships between these variables are summarised graphically in Figure 8.4.

The models presented in this chapter provide a useful approach to the study of the factors that influence student learning using computers in the classroom. This chapter has been mainly concerned with the presentation of the models and results. It has revealed the relationships between the presage, process, and product variables that exist in the various levels of the model. The next chapter provides an overview of the study results and discusses the specific research questions outlined in Chapter 5.

Chapter 9

Response to Research Questions

Introduction

As discussed in the previous chapters, there is considerable evidence that computers can be used to achieve a variety of outcomes in the classroom. The present study investigated the use of computerised databases in classrooms and this chapter provides a summary of the research findings. The aim here is to bring together the results of the analyses reported in the previous two chapters and provide responses to the research questions posed in Chapter 5. Detailed discussion of the findings has been provided in the preceding chapters with Chapter 7 giving a descriptive analysis of the data and Chapter 8 an analysis of the relationship between presage, process, and product variables included in the various models. Some of the research questions can be addressed by focusing on one particular part of the analysis while others need different parts of the analysis to be considered jointly before a full explanation can be given.

Response to Research Questions

1. To what extent did the students learn to use databases during the study?

The effective use of computers and database software is central to the present study. Students were asked to work with a number of databases in various problem solving situations. The Database Knowledge Instrument was used to determine the knowledge that students had of databases and their ability to solve problems using them. As this instrument requires students to use computerised databases, some teachers were concerned that students in their classes who had little experience operating computerised databases would struggle when asked to complete the Database Knowledge Instrument. As it was not the intent of the research project to set students up to fail, it was decided that they would not be asked to complete this testing instrument as a pre-test. Rather, at the beginning of the study students were asked to report their level of previous database experience. Students indicated that, on average, they only occasionally used databases, and although 72 per cent of students reported that they had been taught how to use a database, only about a third of the students had ever used a database to solve problems. Based on these reports it would seem that on entering the study, students did not have a large amount of previous experience using databases, and not much experience using them to solve problems. Consequently it is assumed they would have scored minimally on the database knowledge test. In contrast, towards the end of the study, students scored highly on the Database Knowledge measure (see Chapter 7) indicating that they had achieved a good level of database processing knowledge and skills by the end of the course.

2. Does the use of computers, and in particular the use of computer database management packages, assist students to acquire content knowledge?

This question was addressed by asking students to complete tests that measured their knowledge of the information stored within computerised databases. Specifically, as students worked with the High School and Movie databases they were asked to complete the High School Knowledge pre-test and Movie Knowledge pre-test before they began work with the respective databases. Upon completion of the database activities they completed the High School Knowledge post-test and Movie Knowledge post-test. As there was a significant increase ($p<0.05$) in content knowledge between pre- and post-tests on both of the database content measures, it would seem that students do acquire content knowledge during database activities. However, the study can make no comment on the relative effectiveness of this knowledge construction as it did not compare using databases with other methods of knowledge construction.

The results of the current study give support to the classroom use of computerised databases to assist students in the construction of knowledge. Given that increases in knowledge are important outcomes of learning activities (Alexander et al., 1991), and the growing recognition of the importance of knowledge construction in learning (Edwards, 1996), the importance of this outcome should not be taken for granted. The use of computerised databases may give teachers a way of encouraging students to work with information and construct knowledge. As databases are being used more widely in the workplace, many of these database activities can reflect authentic work practices which should encourage students to become further involved in database learning activities.

3. Does the use of computers, and in particular the use of computer database management packages, help students to increase their procedural and strategic knowledge as reflected in their information processing skills ?

The discussion in Chapter 2 highlighted that databases can be used to help students work with information and develop information processing skills. To further investigate this claim several one-factor congeneric models were developed to measure student Information Processing abilities. These consisted of measures of Hypothesis Testing, Interpretation of Data, Sufficiency of Data, and Association of Data. The Hypothesis Testing scale measures student ability to form hypotheses for sets of categories and/or data. The Interpretation scale measures student ability to interpret the results of their searches and manipulations of data when working with information to solve problems. The Sufficiency of Data scale measures student ability to recognise when they have sufficient data to test a hypothesis and reach a decision. The Association of Data scale measures student ability to recognise information associated with a problem and organise that information in ways that help them solve problems. Throughout the study students made significant gains (indicated by a significant difference using a 2-tailed t-test ($p<0.05$) between pre- and post-tests) in each of these four information processing scales.

To achieve greater parsimony and avoid problems of colinearity, a second order factor analysis was carried out to combine the first order information processing constructs into a second order Information Processing construct. Not surprisingly, students also showed a significant improvement (indicated by a significant difference using a 2-tailed t-test ($p<0.05$) between pre- and post-tests) in their information processing abilities as measured by this scale. It would seem that working with databases does assist students to develop their information processing skills.

4. To what extent is learning within the classroom using a database management package affected by presage factors, in particular the presage factors of: gender, personality, previous computer experience, preferred approach to learning, flexibility in learning, and information processing skills?

This question relates to the analysis of the significant influences on the learning outcomes associated with a number of presage factors in the classroom. The learning outcomes include knowledge outcomes and information processing outcome measures, while the presage factors include student background and intermediate factors. The general nature and pattern of the relationships between these variables and constructs was outlined in the general model for analysis (Figure 5.1) and the specific relationships between variables of interest are detailed in the final fitted model (Figure 8.3). These relationships are important and deserve more consideration.

Gender

Student gender was found to have an influence on database knowledge. A significant positive relationship between gender and database knowledge indicated that males had reached superior database knowledge levels to females by the end of the course. No direct relationships were found between gender and the database content knowledge measures, and gender and information processing.

Gender was found to influence several of the cognitive outcome variables indirectly due to its relationship with computer experience. This was one of the strongest positive relationships found in the study. Males entered the study with significantly more computer experience than females. In particular, males were much more likely than females to own and to use a computer. They used computers more at home, and although the use of computers in the classroom was gender neutral, males made more use of computers in school outside of normal lesson times. Also males used computers at other places (not home or school) significantly more than females. Of particular interest to the present study, males also reported more experience with databases on entering the study. Overall, males reported much higher levels of computer experience than females and, as much of this experience comes from playing games, particularly at home, these experiences can be considered to be positive and enjoyable. As computer experience was found to directly influence information processing skills and student attitudes to computers, gender has an indirect influence on these outcomes.

Gender did not significantly influence student approaches to learning. This result supports previous studies that found little evidence of gender differences in approaches to learning across subjects in Australia (Watkins & Hattie, 1990).

Overall, despite the fact that some authors (for example, Durnell & Thomson, 1997), argue that gender effects in computing subjects are slowly diminishing, the present study found that gender still has a large influence in the computer classroom.

Personality

Personality was related to the pre-test knowledge measure. This result may indicate a general disposition of more introverted students to be more studious generally, however, it is difficult to explain on substantive grounds and is not discussed further.

Previous Computer Experience

The previous experience that students have with computers is an important presage factor in the present study. Computer experience positively influences student information processing skills as evidenced by the positive path in the final model (Figure 8.3) from Previous Computer Experience to the Information Processing pre-test. This pre-test result had a large influence on the final Information Processing outcome measure. It would seem that those students who have used computers more are better able to work with data and information as a result.

Computer experience was found to influence student database content knowledge indirectly through student approaches to learning. Computing experience had a positive influence on student approaches to learning. Those students with more computing experience were more likely to adopt deep and achieving approaches to learning. As an achieving approach was found to directly influence the cognitive outcome measure of post-test High School Knowledge, computer experience indirectly influences this outcome variable.

Approaches to Learning

Student approaches to learning had an influence on one of the cognitive outcome measures. While the Surface and Deep approaches did not directly influence these outcomes, an Achieving approach was found to directly influence the level of post-test content knowledge of the databases used in the study. In particular, those students who reported an achieving approach achieved higher grades on the post-test measure for the High School database. Typically, students who adopt achieving approaches use strategies that enable themselves to perform well. It would appear that in the present study they were partially successful. The absence of any direct influences on the post-test Movie scale, the second of the two database content measures, indicates that the strategies students adopted, although successful in the short term, were not able to consistently keep them performing at superior levels throughout the course. This may have been due to the fact that as the course progressed, and the level of teacher scaffolding was reduced, students were encouraged to assume more of the responsibility for the various computer tasks. Strategies used by the students under conditions of high teacher scaffolding may not have been as successful when students were expected to become more autonomous.

Flexibility in Learning

Although the maladaptive Flexibility in Learning variables had significant negative correlations with some of the cognitive outcome variables, these correlations did not translate into significant influences in the model that included all possible influences. This may be due to the way in which Flexibility in Learning was related to the other variables in the model. However, paths involving Flexibility in Learning were not expected to be large as many adolescents have not fully developed their understandings of higher-level executive control, particularly in relation to the two maladaptive modes of Inflexibility and Irresoluteness (Cantwell, 1998).

Information Processing

The information processing skills that students brought to the study influenced the cognitive outcomes of the study. In particular, these skills had a strong influence on student information processing ability at the end of the study. This ability in turn had a strong influence on their database knowledge and skills, and the level of content knowledge they acquired from the databases with which they worked. It would seem that students' ability to work with information, including associating data relevant to the problem at hand, hypothesising relationships in the data, determining if there is sufficient information to solve a problem, and being able to interpret the result of the manipulation of data, are critical skills for them to possess if they are to successfully work with databases. This link is not surprising as studies have demonstrated a link between information processing skill level and academic performance (Zimmerman & Risenberg, 1997). This may be explained by the role of self-regulation during cognitive activity. If students are to self-regulate during database activities they need to have procedural knowledge on call to allow them to effectively 'fuse' information processed and information processing (Winne, 1995). As students more fully develop information processing skills, the energy required to activate these skills becomes less. This frees working memory so they can self-regulate and allocate cognitive resources to knowledge extraction and monitoring processes (Boekaerts, 1997).

5. What attitudes do students have toward the use of computers?

Generally, students in the current study reported positive attitudes to the use of computers, with their confidence in using computers significantly higher ($p<0.05$) than their liking of computers. They responded that they could work with computers without someone helping them and that working with computers would not make them nervous or uncomfortable. Students were less definite about the use of computers at school. They averaged only slightly positive responses to the concept of having computers in every classroom, learning using computers, and spending more time on computers at school.

6. To what extent are cognitive outcomes and student attitudes to the use of computers in the classroom related?

The relationship between the attitude and achievement outcome variables is of interest. Attitudes were shown to positively influence cognitive outcomes and not vice versa. In particular, student confidence in working with computers had a direct positive influence on the knowledge students had of databases at the end of the course with those students who were more confident reporting higher levels of database knowledge. Also, student liking of computers was found to directly influence the knowledge students had of databases at the end of the course with students who like using computers more reporting higher levels of database knowledge.

The relationship between the attitude constructs led to an indirect influence on database knowledge. Students who were more confident using computers, liked using them more, which in turn had a positive influence on the knowledge students had of databases. The present study, therefore, supports the notion that student attitudes to computers are important as they directly influence achievement outcome measures.

7. To what extent are student attitudes to computers related to the presage variables of: gender, age, personality, preferred approach to learning, flexibility in learning, and information processing ability?

Student attitudes to computers were found to be influenced by several of the presage variables included in the study. The general nature and pattern of the relationships between these variables and constructs was outlined in the general model for analysis (Figure 5.1) and the specific relationships between variables of interest are detailed in the final fitted model (Figure 8.3). Consider now these relationships.

Gender

Gender directly influenced both student computer liking and computer confidence. Boys reported more positive attitudes in both instances with the influence on liking being slightly larger in magnitude than that on confidence. Gender was also found to have an indirect influence on attitudes through its relationship with computer experience. This indirect effect was the same direction as the main direct effect and reinforced the fact that boys had more positive attitudes to computers than girls.

Personality

There were no relationships in the model between Personality and either of the attitude outcomes.

Computer Experience

Students' previous computer experiences directly influence their attitudes to computers. The relationships between Computer Experience and Computer Confidence and between Computer Experience and Computer Liking are some of the strongest in the model (Figure 8.3). The positive paths between these variables in the model indicate that the more computer experience students have, the more confident they will be in using computers and the more they will like using them. Computer Experience was also found to influence attitudes to computers indirectly, particularly Liking through its positive influence on Deep approaches to learning.

Approach to Learning

Student approaches to learning influence their attitudes to computers. In particular, the present study indicates that students who adopt a deep approach will like using computers. This may have been a result of the location of the current study in the Year 9 Computing Studies subject. As students usually adopt a deep approach in subjects that they are interested in, it is not surprising to see students of Computing Studies who report a deep approach also reporting that they like computers.

Flexibility in Learning

Flexibility in Learning was not found to influence student attitudes to computers.

Information Processing

The information processing ability that students brought to the study was found to influence student attitudes to computers indirectly. Student information processing skills at the commencement of the study were found to have a strong positive influence on their information processing skill level at the conclusion of the study. This in turn was found to positively influence both computer confidence and computer liking. Those students who were better at information processing at the conclusion of the study were more confident in using computers and liked using them.

8. To what extent are the cognitive outcomes associated with using a database management package, and student attitudes to computers, dependent on classroom process and contextual factors?

The present study sought to examine the importance of classroom contextual influences on student learning. While no single research project can attempt to measure all of the contextual influences on student learning, the classroom level variables included in the study demonstrated some very interesting influences on student learning. Contextual factors were found to influence cognitive outcomes directly and influence student attitudes to computers indirectly. These influences will now be discussed.

Implementation of the Database Course

As discussed previously, the database course was successful in assisting students to improve their information processing skills, database knowledge, and the content knowledge of the databases on which they worked. Particularly in those classrooms where the teachers were more effective in implementing the database course, students scored more highly on the two cognitive outcome measures of Information Processing and Content Knowledge of the databases used in the study.

Although students working within the database course reported generally positive attitudes to computers, the level of implementation of the course was not found to influence student attitudes directly. It did, however, have several indirect influences on attitudes. The level of implementation of the database course directly influenced student information processing ability, which in turn positively influenced both student computer confidence, and their liking of computers.

Hardware and Software

There were no hardware effects identified in the study, however, the type of software that students used in the classroom affected learning outcomes. Software was found to significantly affect the knowledge and skills developed while working with databases, and the content knowledge that students acquire as they use databases to solve problems. In particular, the use of Clarisworks positively influenced students' knowledge of databases and also positively influenced the content knowledge students acquired of the various databases with which they worked. The use of Microsoft Works version 2 had a negative influence on the content knowledge students acquired of the high school database.

A possible explanation for software differences lies in the style of navigation that the programs require. Those programs that make use of menus rather than requiring the students to use syntax commands may decrease the cognitive load on the student by providing a scaffold during complex activities such as making queries of a database. This may increase student performance by making tasks easier and increases the likelihood that students will engage in self-regulation during computer activities.

Direct Strategic Instruction

During the database course, teachers used direct instruction as a way of informing students how to manipulate data within the databases and develop strategic knowledge. Variation between classes in teachers use of direct instruction did not significantly affect the outcome variables.

Teacher Modelling

Teachers were encouraged to model database skills and strategies for their students. Although the research literature has identified modelling as an effective way to communicate strategies (Collins et al., 1989), the present study failed to find that modelling had a significant influence on student outcomes. A possible explanation lies in the truncated form of modelling that teachers used. Most of the teachers did not have access to the technology necessary to display a computer screen to the entire class. As a consequence, modelling often took the form of the teacher performing database operations and then attempting to describe what was happening on the monitor to the class. Classroom observations suggest that this proved to be less than ideal.

Peer Interaction

Students were encouraged to work in cooperative groups and interact with their peers during problem solving activities. Although peer interaction did not directly influence the outcome variables it did provide a large indirect effect. Those classrooms in which teachers were successful at getting students to interact with their peers were also the classrooms in which the database course was more effectively implemented. This in turn was significantly related to student information processing skills, their knowledge and skills of databases, and their knowledge of the content of the databases with which they are working.

The level of peer interaction also had an indirect influence on student attitudes to computers. Peer Interaction had a strong positive influence on the successful implementation of the database course, which in turn had a positive indirect influence on students' attitudes via post-test information processing ability.

Heuristic

Approximately half of the classrooms in the study made explicit use of the DEAL heuristic to scaffold student performance during database activities. The use of the heuristic did not directly influence the outcome measures. It did, however, have a negative influence on the implementation of the database course. Teachers who did not use the heuristic were better able to implement the database course in their classrooms. Anecdotal evidence from the classroom observations suggests that teachers who used the heuristic struggled to integrate it effectively into the database exercises. The heuristic tended to become an add-on to the problem solving process rather than being treated as an integral part of it. It would seem that the use of the heuristic served to increase the teachers' cognitive load and this limited the way in which they implemented the database course in the classroom.

Student Time on Task

The amount of time that students spent on task during the database lessons was found to influence positively the amount of knowledge that students acquired about databases, and their skill in using them.

Conclusion

This chapter has provided answers to the specific research questions of the study. The use of databases in the classroom was found to be beneficial in terms of both student cognitive outcomes and their attitudes to computers. Various classroom- and student-level variables were found to influence these outcomes positively.

The final chapter provides an overview of the findings of the study, discusses the limitations of the study, and the implications of the research findings. It concludes with suggestions for further research.

Chapter 10

Summary and Conclusion

Introduction

This study investigated the use of computerised databases to enhance student learning in the secondary school classroom. Students completed a course in which they used computers and database management software to solve problems that required them to work with information. The present study investigated the learning outcomes associated with classroom database use and the student factors and classroom processes that influenced the success of these learning activities.

The previous chapters have presented the theoretical basis for the study, described the methodology of the study, presented a description and analysis of the data, and responded directly to the research questions. The present chapter seeks to summarise and conclude this discussion by presenting an overview of the findings of the study, discussing the study's limitations, considering the implications of the study, and proposing future research that would extend the scope of the present study.

Overview of Findings

Western society has become an 'information society' and the use of information is expanding at an ever-increasing rate (Maor, 1993). It is important that students have an opportunity to work with information, learning how to access stored information and how to interpret and manipulate the data they retrieve (Riding & Chambers, 1993). These skills are requisite for full and critical participation in an information society (Shymansky & Kyle, 1991: 5). The current study investigated learning by students through the use of computerised databases. In order to do this, a course was developed which aimed to help students develop information processing skills and assist them in using these skills to solve problems requiring the manipulation of information.

The data concerning the classes, the students and their learning and attitudes were collected using a series of tests, questionnaires, and classroom observations to provide information about presage, process, and product variables associated with database use in the classroom. Overall, students successfully learned to use databases during the study and were able to acquire content knowledge of the databases with which they worked. Students increased their information processing skills and reported positive attitudes to computers during the study.

The 3P model (Biggs & Moore, 1993) was used to provide a theoretical framework for the study and a number of factors were found to influence the success of database activities. The present study confirmed that gender is still an important presage variable in the computer classroom as gender was found to influence both cognitive and attitudinal outcomes directly. A student's previous computer experience was also found to be very important as it directly influences information processing ability, approaches to learning, and attitudes to computers. Student approaches to learning were also found to influence both cognitive and attitudinal outcomes with deep approaches influencing computer liking and achieving approaches influencing knowledge outcome measures.

Generally, students reported positive attitudes to computers and were happy to work with databases throughout the course designed for this study. Particularly in the last section of the course as they worked on a number of 'authentic' research projects, students were highly motivated. During this time most students completed very successful data collection and analysis activities that ranged from investigating nutritional information about breakfast cereals to information on sporting feats. Most teachers were pleasantly surprised at the level at which their students worked. The current study also found that student attitudes to computers directly influence student achievement. This served to emphasise the importance of developing appropriate attitudes in computer classroom learning activities.

Several classroom contextual variables were found to be important. Peer interaction during cooperative learning activities contributed to a rich cognitive environment as did the amount of time that students stayed on task. Also, the type of database software students used was found to influence learning outcomes directly. Those students working on menu driven rather than command driven databases performed significantly better on achievement outcome tasks. Other teaching methods were of interest because of their negative influence, or failure to influence, learning outcomes. The use of the DEAL heuristic was found to be a negative influence, while direct instruction of strategies and teacher modelling of strategies failed to influence outcome measures.

Overall, the use of databases helped most students to develop information processing skills and to work with data. They provided an appropriate context for students to engage in the construction of knowledge and develop skills for the information age.

Limitations

The 3P model of the classroom presents a dynamic system of influences acting upon the outcomes of interest in this study. These influences have been shown to be complex and interrelated. It has not been possible for the current study to investigate all possible influences using the evidence collected by the instruments and classroom observations. Given the limitations of the sample, and the inherent limitations of the instruments used, it was impossible for all relationships to be investigated. Nevertheless, it is possible on the basis of the available evidence to draw implications from the research findings for both teachers and students regarding the use of computers.

It is important to acknowledge the limitations of the present study as they help guide the application of the findings of the study. These limitations warrant further consideration and are discussed in terms of the sample, the measurement of outcomes, and the overall methodology of the study.

The Sample

Classes in which Year 9 students were studying School Certificate Computing Studies formed the primary sampling units of the study. Some important limitations of the study relate to the sampling procedures. Firstly, it was not feasible to draw a random sample. Students needed to have access to computers to complete the database course successfully. As Computing Studies was the only subject in all schools that could offer this access, the sample was restricted to students in Computing Studies classes. The restriction of the study to the geographical area of the Hunter region was a further practical limitation on the sample of students.

Secondly, by necessity, the teachers involved in the study were all Computing Studies teachers. This meant that they had levels of computer proficiency that would be above that of teachers of most other subjects throughout the curriculum. Without similar levels of computer access and teacher technical expertise, results from the current study may not generalise across the curriculum. Also, as many of the database activities asked students to work with content that had been artificially placed within the Computing Studies curriculum, the benefits associated with working with information that is situated in relevant contexts were not optimised. Many of the database activities, especially the hypothesis testing and project work would have been more appropriately situated within various other subjects in the broader curriculum. Unfortunately access to computer hardware within other subjects made this virtually impossible.

The sample in the present study involved schools, teachers, and students. The hierarchically nested nature of these three groupings led to the adoption of multilevel techniques in the analysis to allow for this clustering, and to consider any effects at class and school levels. In an optimal balanced multilevel design (Mok, 1995) there would be approximately equal numbers of classes in each school and equal numbers of students in each class. However, such a study may have reduced ecological validity. The present study had an unbalanced design as do most quasi-experimental research studies. In the present study, four of the schools had a single class while seven schools had two or more classes. While 11 of the teachers taught a single class, four teachers taught more than one class. The average number of students per class was 14. However, the sample included one class in which there were only four students and two classes in which there were only eight students.

Overall, although the sample was the largest that could be managed given available resources, and the fact that schools and teachers had to be volunteers, it was adequate to test the hypotheses and provide answers to the research questions outlined in Chapter 5. In doing this, the small sample meant that some consolidation of constructs was necessary (for example, Information Processing) when use of the separate measures may have been of interest.

The Measurement of Student and Classroom Variables

The study relied on questionnaires, achievement tests, self-report surveys, and classroom observations to gather information about classrooms and students. Particularly in the self-report surveys, students were asked to reflect upon their attitudes, approaches to learning, and flexibility in learning. Even though student perceptions are unlikely to change rapidly, the reliance on a cross-sectional survey to determine these variables must be recognised as a limiting factor in the study.

The ability of the study to explore only a small part of classroom interactions is a limiting factor in drawing conclusions relating to classroom variables. Some of the classroom level variables were not found to affect learning outcomes. Although these variables were included based on evidence from the literature indicating their importance, it is possible that the relatively small number of classroom observations, and the fact that different classrooms were observed at different times, for different lessons in the database course, limited the assessment of classroom variables of interest.

The measurement of student knowledge of, and ability to use, databases relied on the Database Knowledge measure. This measure contained both theoretical and practical components for reasons explained in Chapter 7. This measure was not administered as a pre-test, rather student levels of database knowledge entering the course were determined using a self-report measure. This limited the ability to be able to determine if student Database Knowledge had increased during the course.

The way the outcomes constructs were measured may have curtailed the results of the study. During the study students were encouraged to engage in cooperative learning. The benefits of this have been outlined in the study and students enjoyed working in groups. The assessment of the outcome constructs, however, was conducted individually with students working alone. This change in context may have influenced both performance and attitudes.

Overall, although the range of variables was limited, the variables were carefully selected and they formed reliable measures.

Methodology

Several methodological factors need to be considered as one reviews the findings of the present study. Although the sample size was sufficient for large group statistics to be used, it was reduced due to missing data in the sample. As the present study was conducted in real classrooms over an extended time frame (10 weeks) it was inevitable that some students would miss part of the program. While this did not prevent the study from continuing, a more complete data set may have served to further strengthen results and make results more robust.

Several one-factor congeneric models were developed during the study using LISREL8. Generally, these models were a very good fit to the data with high reliabilities. Some of these models differed from those developed using principal component analysis in previous studies. When this occurs it is often a matter of weighing representation of content against reliability of the measure. The present study adopted the position that although content is of importance, unless a scale can be used to measure a construct reliably, outcomes for that scale should be questioned. Different models were developed when there were marked improvements in reliability available.

Although advanced statistical techniques were used in this study, one must carefully examine the statistical results and be aware of the limitations. The present study tested a multilevel path model and found that it provided a satisfactory fit to the data. This implies that the data supports theory, however, it should be remembered that the model had not been proved. Rather, the model has not been disproved (see Chapter 5). In other words, although not proving outcomes, this study adds to our understanding of the use of computerised databases in the classroom. It contributes evidence as to the worth of databases, and ways to effectively utilise them in classroom learning.

Implications of Research Findings

Educators are constantly looking for ways to help students acquire the necessary knowledge and skills to move towards expertise in respective domains. The continual expansion of technology in society has led to a redefinition of the knowledge and skills that contribute to expertise. Although expertise generally involves the acquisition of a large amount of domain-specific knowledge and skills, the ability to access outside information is seen as important. If experts can not recall the necessary information they need to solve a problem, the ability to retrieve and work with other information enhances the likelihood of success. It is no coincidence that information skills are being seen along with literacy and numeracy as some of the most important skills for students to develop.

The present study has highlighted that students can learn to use computer technologies, and particularly databases, successfully in the classroom. As students work with databases they acquire content knowledge of the specific database with which they are working, as well as developing skills in information processing. These information skills are directly related to achievement measures and positive attitudes to computers. Such promising results should serve to encourage all teachers to use database technologies wherever appropriate throughout the curriculum.

Factors that Influence Learning with Databases

Many factors have been identified that may affect the use of technology in the classroom. The present study highlighted the gender influences that were found to have a significant affect on learning outcomes. Boys were found to have more positive attitudes to computers, and to acquire more database knowledge and skills, than girls. Possible reasons put forward to explain these gender differences include computer experience, stereotyped attitudes, perceived usefulness of computers, attributions, associations with male oriented subjects, parental attitudes, socialisation patterns, and the lack of female role models for computing. The range of these explanations leaves the impression that the reasons for the gender effect are complex in nature and most certainly not straightforward. Although some gains have been made in gender differences over the last decade, it is important that educators continue to work to provide more equitable classrooms. Increased use of computers across the curriculum by both male and female teachers may help facilitate more gender equity. Also, more computer experience may help girls to increase performance and develop more positive attitudes to the use of computers.

The present study highlights the central role that computer experience can play in classroom learning. Computer experience was associated with better information processing skills, more positive attitudes to computers, and deep and achieving approaches to learning. Teachers need to assist their students in gaining experience using computers. The home has been identified as one environment in which students may obtain computer experience. Unfortunately, not all households are in a position to afford a computer. The experience that students gain using computers at school, therefore, is of great importance. Teachers need to ensure quality experiences, that is, the use of computers to perform higher order, authentic tasks throughout the curriculum. Many teachers are not in a position to do this as they lack computer knowledge and skills. Governments, school districts, and schools need to place a high priority on providing adequate training to equip their teachers with the requisite skills.

The approaches to learning that students adopt influence learning outcomes. Deep and Achieving approaches were associated with positive classroom outcomes. Wherever possible students should be encouraged to adopt these approaches. Biggs and Moore (1993) argue that minimising extrinsic motivation, a cold classroom climate, excessive workload, and excessive and inappropriate assessment will help to discourage surface approaches. Deep and achieving approaches can be encouraged through a use of a rich knowledge base, an appropriate motivational context, interaction with others, and learner activity (Biggs & Moore, 1993: 478). It would seem that student approaches to their learning do not occur by chance but may be influenced by good pedagogical practice.

Student development of higher order thinking skills and metacognitve skills is another area that has been associated with good teaching methodologies. These skills do not develop by chance but are the product of a rich cognitive environment established through a consistent effort on behalf of the classroom teacher. The present study attempted to create such an environment throughout the database course through the use of cooperative learning, teacher modelling, heuristics, and the direct instruction of strategies. Effective implementation of the course was found to increase student information processing ability and database content knowledge directly, and to encourage positive attitudes to computers indirectly. Not all of the teaching methods were as effective as others. Teachers struggled with modelling owing to a shortage of classroom equipment, such as projection facilities, which would enable students to watch them in action as they complete computer-based tasks. Without this expensive equipment teachers found it hard to model database strategies effectively. Fortunately, projectors are dropping in price making them a more affordable option for classrooms.

Teachers found the DEAL heuristic hard to integrate into database lessons. Although it was embedded into the respective activity worksheets, the heuristic was most often seen as an add-on to the database activities rather than integral to them. This may be a reflection of the inexperience of classroom teachers in teaching metacognitive skills, and the poorly developed metacognitive skills of the students. Anecdotal evidence suggests that, for many teachers, this was the first time that they had actively taught metacognitve strategies and, many students were not used to overt metacognitive activity. For example, when students were asked to solve a problem using a database, most of them preferred to commence using trial and error techniques rather than stopping and planning strategic activity. The implication here is that teachers need better training in the use of heuristics and the instruction of metacognitive skills. Alternatively, heuristics in general, or this one in particular, may not be useful for teaching metacogniton. Irrespective of the success of teaching strategies, students need to practise metacognitive skills and experience success using them to build an appreciation of their worth.

Cooperative learning was very important to the success of the database activities. Within their groups, students interacted frequently during problem solving activities. Students enjoyed working with their peers and their enthusiasm for many of the activities was evident. Particularly during the project, most cooperative teams worked together to complete the task at hand successfully. In some classrooms where there were enough computers for one for every student, it took some time for students to leave some computers turned off and work in groups using only the one computer. The quality of their work did benefit as a result. While this study did not attempt to investigate group structure and dynamic, it was clear that the use of cooperative groups did enhance the database activities.

Generally, students reported positive attitudes to the use of computers. Positive attitudes are important outcomes in themselves and educators should recognise the role that computers can play in enhancing the quality of student experiences while at school. Student attitudes to computers may be influenced by the quality of classroom experiences compared to previous computer experience. As many students have a background of experiences using computer games, if classroom experiences do not match the level of sophistication of these games, students may not necessarily report positive attitudes to the use of computers in school. One of the positive aspects of databases, and other productivity software, is that they do not rely on a game format and they encourage students to view the computer as a tool that can help them accomplish otherwise difficult tasks. Student attitudes to such tools used within authentic, meaningful contexts is likely to remain positive.

Attitudes may also be important for other reasons. The present study supports a link between attitudes and achievement. Those students who reported more positive attitudes to computers achieved higher results on the cognitive outcome measures. As teachers encourage their students to develop positive attitudes to computers, they may also see these students make achievement gains. One important way of encouraging positive attitudes is to increase students' computer experience. As students gain more experience using computers, they become more confident in using them and like using computers more. The quality as well as the quantity of this experience is important. Not all experiences with computers are received equally. Girls have consistently shown a definite preference for certain computer activities. If they are engaged in computer activities that they dislike, or activities that they find too difficult, their attitudes to computers may deteriorate with increased computer experience.

Overall, the present study found that the use of computerised databases may enhance classroom outcomes. Databases may be used to help students acquire domain knowledge, and develop information processing skills and positive attitudes. These outcomes do not occur by chance, but rather are the result of classroom pedagogies that emphasise the development of these knowledge, attitudes, and skills.

Further Research

The present study concerns the use of computerised databases in the classroom to enhance student learning. The previous sections have outlined the findings of the study and discussed the implications of these findings. Further research may be conducted in a number of areas to extend the study's findings.

Firstly, the present study was situated with the subject of Computing Studies. While this provided the computer access necessary for student participation in the database course, it forced students to work and gain database experience in a computing subject that is outside of other school subjects. The logical extension of the present study is to research database use in other curriculum areas, that is, study the impact of the use of databases within subjects such as Science, History, Geography, and others. The logistical factors surrounding computer access would have to be overcome, however, studying the use of databases to engage students in authentic tasks throughout the curriculum would be of benefit.

Secondly, a better understanding is needed of the way in which students work with database software, and the problems which they wrestle with during information processing activities. This research may require a qualitative rather than quantitative focus and would be seen as complementing the present quantitative study. Also, the present study used a database course that was completed during a 10 week term. It did not seek to address the issues of knowledge and skill retention and transfer. Further research studies could address these issues using a longer time span and wider curriculum coverage.

Several one-factor congeneric models were developed during this study. All of these models showed a good fit to the data. However, the development of models from the data in the main study has the potential for capitalising on chance factors in the data. Further research studies could confirm the stability of the developed models by cross validation of the developed models on a new sample.

Another possibility relates to the content of the general model. The results of the structural equation model are restricted to the variables and factors specified within the model context. Other variables, outside of the model that are not specified, may also affect the outcomes. A search of the literature revealed factors that may affect student learning in the computer classroom but logistical factors prevented all such factors being included in the study. Further research may extend the current study to consider factors such as socio-economic status, student attributions, parental attitudes, teacher presage variables, teacher attitudes, and other teaching strategies. Also, the present study made use of one observer making five visits to each classroom during the database course. A more detailed observation schedule may provide a richer body of data that may increase understanding of the factors surrounding the processes involved in student database use in the classroom.

Conclusion

The use of computers in education has been implemented at the school level, but not yet at the teacher level (Pelgrum & Plomp, 1993). Most schools have followed quite simplistic introduction strategies, based upon the assumption that the provision of hardware and software will automatically result in fundamental changes to classroom instructional practices. The present study seeks to clarify the role of information technologies in the classroom. While innovators are quick to use the latest technologies, little research has focused specifically on how student learning is facilitated by the computer in the classroom (Moar, 1993). Many people are consequently left wondering as to the worth of expensive computer technologies.

The current study has focused on the classroom use of computers, and more specifically the use of computerised databases. It has made a concerted effort to model the ecological reality of schools and classrooms in an effort to identify the factors associated with positive student outcomes. The study identified knowledge construction, information processing skills, and positive student attitudes as outcomes of database use and highlighted the influence of gender, computer experience, and student approaches to learning on the success of database activities. It also emphasised the role of the classroom teacher and various teaching methodologies in the classroom. The study was encouraging because the database course developed during the project was successful in helping students work with databases, especially when students remain on task and are encouraged to work in groups.

This study was an example of looking at the potential use of one 'technology' application in the classroom. There is a need to look at others, and more critically than is often the case. Technology is not the panacea for all classroom difficulties, however, in combination with effective teaching practices it may help students acquire knowledge and skills that enables their more active participation in today's global information society.

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Appendices

Table of Contents

Appendix 1

Database Course

Appendix 1.1 Database Course

The database course consists of four sections. Section 1 engages the students in exercises that introduces them to databases and teaches them the mechanics of how to manipulate data contained in a database. Section 2 introduces students to problem solving and hypothesis testing using databases. Section 3 provides the students with a database shell and they are requested to build the database file, while section 4 involves the students in a research project in which they create their own database file. Table A1.1 shows a schedule of the various lessons included in the database.

Table A1.1 Database Course Schedule

Week 1	Introduction Lesson and Testing Instrument 1	Introduction to Databases	Testing Instrument 2	Database Terminology
Week 2	Browsing /Layout /Arranging	Browsing /Layout /Arranging	Testing Instrument 3	Arranging / Sorting
Week 3	Testing Instrument 4	Selecting Records (find)	Selecting Records (find)	Selecting Records (find/sort)
Week 4	Selecting Records (find/sort)	Hypothesis Testing High School Database	Hypothesis Testing High School Database	Hypothesis Testing High School Quiz
Week 5	Hypothesis Testing World Database	Hypothesis Testing World Database	Hypothesis Testing World Database	Hypothesis Testing World Quiz
Week 6	Hypothesis Testing Movie Database	Hypothesis Testing Movie Database	Hypothesis Testing Movie Database	Hypothesis Testing Movie Quiz
Week 7	Building a Datafile	Building a Datafile	Building a Datafile	Building a Datafile
Week 8	Creating a Datafile	Creating a Datafile	Creating a Datafile	Creating a Datafile
Week 9	Creating a Datafile	Creating a Datafile	Creating a Datafile	Creating a Datafile
Week 10	Creating a Datafile	Testing Instrument 6	Testing Instrument 7	Testing Instrument 8

While the database course was developed for the hardware and software combinations of: Microsoft Works 2 (IBM), Microsoft Works 3 (IBM), Clarisworks 2 (Macintosh), and Appleworks (Apple IIe), the following copy is for Clarisworks 2 (Macintosh).

Computing Studies

Information Systems

Database Course Index

Lesson Name (Number)

INTRODUCTION LESSON

Lesson 1

Objectives:

By the end of this unit students should:

- become motivated to be actively involved in the unit
- appreciate how databases can affect the lives of people
- fill out the consent form
- complete Testing Instrument One.

Materials:

Testing Instrument One
Testing Instrument Answer Sheets

Preparation:

Presentation:

1. Introduce study and programme to students.
   Explanation of why computers are important.

2. Consent letters.

3. Testing Instrument One.

INTRODUCTION LESSON

Lesson 2

Objectives:

By the end of this unit students should:

- become motivated to be actively involved in the unit
- appreciate how databases can affect the lives of people
- discriminate between problems that can and cannot be solved using computers

Materials:

TV database cards
Sheet for 'DB users at School' and overhead if they require it

Preparation:

TV database cards photocopied and cut - at least 4 per student
School users of database approached before hand to see if they are willing to come and talk about their use of databases at school. Give them the 'DB users' sheet to fill out as a guideline to the type of information they might like to talk about.

Presentation:

1. Relate how many computers an average person can interact with during the day.

2. Explain how databases are extremely important tools that help to store and organise information

3. Invite Librarian/Bursar/Registrar/Deputy to explain how they make use of databases in the school. Inform students of cards that have been completed by staff listing database use around the school.

4. Hand out TV program cards for students to each fill out 3 (encourage them to use different programs from each other and programs of different ratings - ratings are their own subjective scale of 1 to 5 stars.

5. Divide students into groups of 4-5 (making 12-15 cards per group) and have them discard any double up cards and replace them with new programs.

6. Have the groups each appoint a sorter, and race the groups against each other at sorting the cards into order based on a particular field. Note the times of each group on the board.

7. Change the person doing the sorting and race them sorting based on another field.

8. Continue changing the sorter and the field until everyone has had a turn.

9. Look at the times on the board and ask the students how long they think it would take a computer to do the same tasks.

10. Discuss advantages of using a computer database over the manual methods. (Ease of updating, speed of retrieval, speed of sorting, storage of large amounts of data in a small space)

DATABASES USED AT SCHOOL

JOB TITLE:

PERSON:

NAME OF DATABASE FILE:

NAME OF DATABASE PROGRAM:

PURPOSE OF DATABASE:

FIELD NAMES **FIELD TYPES** (if known)

No of Records:

Size of File in Kilobytes:

How often updated:

Any back-up or security procedures?

TV Data Cards

NAME:

CHANNEL:

SCREENING TIME:

LENGTH:

COUNTRY of origin:

RATING (1 to 5 stars)

TV Data Cards

NAME:

CHANNEL:

SCREENING TIME:

LENGTH:

COUNTRY of origin:

RATING (1 to 5 stars)

TV Data Cards

NAME:

CHANNEL:

SCREENING TIME:

LENGTH:

COUNTRY of origin:

RATING (1 to 5 stars)

TV Data Cards

NAME:

CHANNEL:

SCREENING TIME:

LENGTH:

COUNTRY of origin:

RATING (1 to 5 stars)

TV Data Cards

NAME:

CHANNEL:

SCREENING TIME:

LENGTH:

COUNTRY of origin:

RATING (1 to 5 stars)

TV Data Cards

NAME:

CHANNEL:

SCREENING TIME:

LENGTH:

COUNTRY of origin:

RATING (1 to 5 stars)

Lesson 3

Objective:

By the end of the lesson the students should:

- have completed Testing Instrument Two.

Materials:

Testing Instrument Two booklets
Testing Instrument Two answer sheets.

Preparation:

Presentation:

- Administer Testing Instrument Two

TERMINOLOGY

Lesson 4

Objective:

By the end of this unit students should:

- be able to illustrate the difference between data and information
- be able to recognise that a database and a filing cabinet are alike
- define the terms and concepts of file, field and record

Materials:

Preparation:

Prepare Overhead Transparencies 1, 2 & 3
Photocopy class sets of Worksheet 1 & 2
Class set of Blank student information cards.

Presentation:

1. Use OHT 1 to illustrate that data without headings or order can be useless. Ask class for possible meanings or headings for each data item.

2. Use worksheet 1 and complete questions 1 and 2.

3. Use OHT 2 to discuss the actual headings. Stress that no matter what headings are used the data has been organised into information and that headings can give different meanings to the same data.

4. Complete worksheet by answering question 3.

5. Have students each fill out an information card (see materials).

6. Collect cards and place them in a pile on the front table. Use them combined with OHT 3 to explain how the data from each student has been organised under the appropriate headings to give information.
   Each heading (piece of information) is a **field.**
   Each card a **record.**
   A set of cards is a **file.**

7. Use worksheet 2 (Exercise) to create more examples.

8. Lead students through the exercise of entering the information from the cards into a simple database that they construct using Clarisworks. The database needs to have only four fields and if there is not enough time for each of the students to enter all the information themselves, the teacher can help them cut and paste other students entries to compile a complete set.

   (Optional) Working with information on card files. Scatter the cards on the floor. Have some students sort these into categories e.g. Male/Female; Birthdays which fall before and after June 30; girls whose birthdays fall before June 30; Boys with blonde hair.

NB. Keep student information cards as they will be used in the next lesson.

SURNAME:
GIVEN NAME:
SEX:
HAIR COLOUR:
BIRTHDATE:

SURNAME:
GIVEN NAME:
SEX:
HAIR COLOUR:
BIRTHDATE:

SURNAME:
GIVEN NAME:
SEX:
HAIR COLOUR:
BIRTHDATE:

SURNAME:
GIVEN NAME:
SEX:
HAIR COLOUR:
BIRTHDATE:

SURNAME:
GIVEN NAME:
SEX:
HAIR COLOUR:
BIRTHDATE:

SURNAME:
GIVEN NAME:
SEX:
HAIR COLOUR:
BIRTHDATE:

SURNAME:
GIVEN NAME:
SEX:
HAIR COLOUR:
BIRTHDATE:

SURNAME:
GIVEN NAME:
SEX:
HAIR COLOUR:
BIRTHDATE:

Overhead Projector Transparency 1

BLUE
SKY
1998
JAMES
HAZELTON
2282
4739

Overhead Projector Transparency 2

SURNAME
FIRST NAME
STREET NUMBER
STREET NAME
TOWN
POST CODE
DISTANCE TRAVELLED

BROWSING/LAYOUT/ARRANGING

Lessons 5 & 6

Objectives:

By the end of this unit students should:

- learn three different ways to browse through a database.
- understand the difference between the different views of a database.
- learn how to create different layouts of a database containing only the desired fields.

Materials:

Two prepared database files using datacards from previous lessons i.e.
TV datacards and student datacards.
Class set of computers or one to a group of students.

Preparation:

Transfer the data from the cards (TV and Student cards) into database files and have theses files on the class computers' hard disks.

Presentation:

This lesson will run for two periods.

1. Open "Students" database file.

2. Familiarise students with screen.

3. Demonstrate three methods of **browsing** through database:
   - Using bookmark to scroll up and down through file.
   - Using the flip cards to flip over one record (forward or backwards) at a time.
   - Using vertical scroll bar on screen.

4. Different **Views**
   - List View **ON** i.e. ticked (found under Layout menu) displays a continuous list of all records down the screen.
   - List View **OFF** i.e. not ticked, only one record is displayed at any one time.
   - Page View **ON** i.e. ticked (found under View menu) displays database page as it will be printed. If the data has been set to appear in more than one column then it will appear only in columns when page view is switched on. Also when page view is on, list view is inactivated.

5. Changing **Appearance** on screen (**LAYOUT**)
   - Explain two basic modes **BROWSE** AND **LAYOUT**
   - Browse for looking at data, layout for rearranging screen layout of data.
   - Practise switching between them. NB. It is necessary to be in Layout mode to change the format of the fields, e.g. currency, percentage etc.

6. Making a **NEW LAYOUT**
   - Explain the difference between Standard and Columnar Report layouts
     Standard - fields one underneath each other
     Columnar Report - Fields list across the screen in columns

   - Create a New Layout. Make it a columnar report layout. Name it 'All Fields'.
   - In the Set Field Order window move **all** the fields across, then return to **Browse** mode

   - Create another New Layout. Make it a columnar layout and name it 'Birthdays'.
   - This time only take across the First name and Birthdate, then return to **Browse** mode.
   - Take a look at the bottom of the Layout menu now. It should contain three layouts (Layout 1, All Fields, and Birthdays).

7. **MODIFYING A LAYOUT**
   - If you wish to add a field to an existing layout, use the **Insert Field** option under the layout menu. This window displays those fields which are not already present in the current layout.
   - Have a look at the **Insert Field** window whilst in each of the three layouts to confirm which ones still have fields available to insert. The Insert Field option is only activated when in Layout mode.

8. **DELETING A LAYOUT**
   - Often new meaningless layouts are created accidentally and your list of different layouts becomes too long. To delete a layout, be sure it is ticked, i.e. the current layout in use, then choose **Delete Layout** from the layout menu.

9. **RENAMING A LAYOUT**
   - Often layouts may be meaningless if their title doesn't inform you as to what they contain. i.e. Layout 1, Layout 2, Layout 3 etc. are meaningless. To rename a layout go to **Layout Info** whilst in the layout you wish to change and it will allow you to change the name.

10. **ADDING A HEADING**
    - A heading gives a printout more meaning.
    - Go to **LAYOUT** mode.
    - Stretch the HEADER downwards by dragging with the mouse the line separating the header from the body.
    - Click on the text tool **A,** then click in the Header space in a position where you wish to enter the heading. After entering it, make the heading a suitable size, style and font. Position it using the pointer tool

    - Return to **BROWSE** mode.

11. **SELECTING A RECORD**
    - Show the difference between selecting a whole record (it all turns black) or selecting just a field within a record for editing (only the field turns black)

12. Hand out worksheets for students to practise and become familiar with the features covered in this lesson.

BROWSING/LAYOUT WORKSHEET

Use the TV Program database file to do the following activities.
All answers are to be written on an A4 sheet of paper and kept in your folder:

1. Turn off List View and flick through the first 5 records and back to 1 again, one at a time using the flip card. What is the name of the program stored in record 4?

2. Turn on List View. What is the country of origin of record 30?

3. Display the data in 2 columns i.e. Layout - Layout Info - 2 columns across first. **N.B.** The columns will not appear if page view (under Page Menu) is not switched on.

   What is the name of the program stored in record no 20?
   N.B. To find out which record is actually number 20 after using the bookmark to get to it, you will have to select a record with the mouse so that it turns black, then see what number comes up in the bookmark.

4. Display the data in 3 columns.
   Use the bookmark to go to record 11. What is the country of origin of the program in record 11?

5. Return the data to 1 column.
   Make a New Layout as a columnar report layout called **Rating.** Only move across the program and rating fields. Use this view to find the name of the programs between records 30 and 40 with a rating of 4.

6. What was an advantage of this new layout called Rating?

7. Create a New Layout (columnar) called Channel & Rating. This layout should contain the program, channel and rating fields. Find the program on channel 10 which has a rating lower than 3.

8. Is there an easier way to find the answer to the question above?

9. Use the Layout menu to return to the Rating Layout. Go into Layout mode and choose the **Insert Field** option. This window now shows the fields which have not yet been placed in this layout. Use it to add the Country of Origin field. The position of the field name and field contents will need to be placed correctly. Use the pointer tool to drag the field name into the header. Then position the box for the field contents underneath it but in the body.
   Then return to browse mode.
   Which Country has the most programmes with a rating of 5? How many?

10. Make a New Layout (columnar) and call it Length. Move across the fields for Program, Channel and Length. Which channel has the most 30 minute programs?

11. Write down why you think it is useful to be able to create different layouts.

12. When is page view used or necessary?

13. What happens when list view is switched off?

14. What is the difference between browse mode and layout mode?

15. List the menu sequence you would go through to rename an existing layout assuming you were not already in that layout to start with.

16. If you were in a particular layout that only had 2 fields inserted out of a possible 5 what menu sequence would you go through to insert another field?

17. Suppose your list of layouts became cluttered with many that you had mistakenly made. How would you go about deleting the unnecessary ones?

18. List the steps involved in adding a header to a layout.

Lesson 7

Objective:

By the end of the lesson the students should have:

- completed Testing Instrument Three.

Materials:

Testing Instrument Three booklets and answer sheets.

Preparation:

Presentation:

1. Administer Testing Instrument Three

ARRANGING/SORTING

Lesson 8

Objective:

By the end of the unit students should:

- be able to sort a ClarisWorks database.
- recognize the way to DEAL with problems.

Materials:

One Computer per Group
Worksheet on Sorting
DEAL Strategy Sheet

Preparation:

Have class set of worksheets and strategy sheets photocopied
Have TV database on hard disks

Presentation:

Teacher should first demonstrate to the class the following sort capabilities of a database management program. If an OHP panel or other such device is not available then the teacher should lead the class through the first initial sorts as one group before they begin work on the worksheet. It is important for the teacher to model the sorting procedure for the class.

The contents of fields can be arranged (sorted) alphabetically, numerically or chronologically (date).

1. Open the "Students" database

2. **SINGLE SORT** (Alphabetical)

   - Use the ORGANISE menu and select SORT RECORDS
   - The Sort Records window allows you to choose which field you want to sort by.
   - Choose Surname, move it across, select Ascending order and OK.
   - Notice the information window to the left now tells us the status of the Records, i.e. Sorted.
   - Scan through the records and notice any students with the same surnames. Have they been sorted correctly i.e. did the first name have any effect ?
   - If there are two or more records having the same data in a field, a further field is needed to sort them. This field is called the secondary field as it is only used if the records have the same data in the primary field.

   In the standard layout where all the fields are listed in a block down the page for each record it is difficult to see how the sort has turned out.
   Use the Layout menu to select the All Fields Layout created last lesson. This layout should show all the fields listed across the screen.

3. **SORT with a secondary field**

Use the ORGANISE menu, select SORT RECORDS, Clear the old Sort Order.

- Then sort as follows:

Sex	Descending	(primary field)
Surname	Ascending	(secondary field)

- This should show all the males first, with them sorted in alphabetical order by surname.
- Check that this has occurred.

4. **SORT with a third (tertiary) field**

Clear the old sort order.

- Then Sort as follows:

sex	Ascending	primary field
hair colour	Ascending	secondary field
surname	Ascending	tertiary field

- Examine the outcome.
- Within the females, blondes come before brown, but within the blondes or browns the students are listed in alphabetical order by surname.
- This shows a sort which is 3 layers deep.

When sorting by more than one field, move the most important field into the SORT ORDER box first, followed by the next most important etc.

5. **SORTING by Date**

- Clear the old sort order.
- Sort by birthdate.
- Examine the result.

6. **Sorting can not be easily completely undone**

The last sort done can always be undone from the EDIT menu. However the records cannot be returned to the original entry order, i.e. the order before any sorting was carried out. When you carry out a sort, Clarisworks renumbers the records so you cannot return to the initial order.

7. **Importance of good strategies to solve problems.**

Relate the Story of Dick Smith attempting to fly a helicopter from the North Pole to the South Pole. In particular stress the need for good problem solvers to plan, check, and evaluate.

Australian adventurer Dick Smith wished to fly from the North Pole to the South Pole. He had already successfully completed a flight in a helicopter around the globe at or near the equator. The first thing he did was to **define the problem** and decide what it was he really wanted to accomplish. Did he wish to use a helicopter or a plane? Had the trip, or one like it ever been done before? He finally settled on the attempting to fly to the North Pole in a helicopter, something that had never been done before.

He then started to **explore alternative approaches** to the problem of flying to the pole. He had to plan how he was to attempt the flight. He planned the flight route, the fuel stops, the support plane he would need and other important considerations.

a. What other important considerations did he have to plan for?

In April of 1986 he **acted on his plan** and set off on his journey. As he flew closer to the North Pole he had to keep checking how the flight was going. In particular he had to check his fuel, that all the instruments of the helicopter were operating correctly in the extreme cold, that he was on course etc...

b. What are some other things that Dick would have to check on his flight?

c. What should he do if something was not right when he checked it? eg. what if he was slightly off course?

Unfortunately the weather closed in, and the temperature in the unheated cabin of the helicopter dropped to -38°C. The navigation instruments of the helicopter began to fail and he had to abandon his trip. He didn't give up though and went home and **looked at the effects** of what he tried to achieve by making a thorough evaluation of his trip. He tried to determine where things went wrong and what he could do to improve the trip next time to make it more successful.

d. What things do you think that Dick would have gone over in his evaluation?

Dick Smith attempted several other flights to the North Pole in his helicopter and was successful on his third attempt in April of 1987. On each flight he planned, checked and evaluated and this led to his eventual success. If you wish to be a good problem solver you need to **DEAL** with problems as Dick Smith did.

Go over question 1 of the worksheet with the class and get them to fill in the four things successful problem solvers do.

Give them the copy of the **Deal** strategy sheet and discuss the various questions that can be asked at each stage of the strategy. Complete question 2 as the class observes you using the computer as you model the **Deal** strategy. Tell the students not to lose the strategy sheet as they will be referring to it a number of times during the course.

Ask the students to complete the rest of the worksheet by following the DEAL strategy. It is preferable that students work in groups as they answer the problems on the worksheet. Encourage them to discuss the solution to the problem using the DEAL strategy. Each student should write their group answers on their own individual worksheet.

SORTING WORKSHEET

NAME:____________________________

Open the TV database to answer the following questions.
Make sure you have all the data fields displayed in a columnar report layout.

1. How many programs begin with the letter H?

Plan: ____

Answer: ____

2. Which Australian program has a rating of 1?

Plan: ____

Answer: ____

3. How many programs have a rating of 5?

Plan: ____

Answer: ____

4. How many programs start at 8:30 pm?

Plan: ____

Answer: ____

5. How many programs are listed in the database for Channel 10?

Plan: ____

Answer: ____

6. How many English programs are listed?

Plan: ____

Answer: ____

7. What is the program on Channel 2 which is further down the alphabet?

Plan: ____

Answer: ____

8. What is the earliest screening program on Channel 9 that is included in this database?

Plan: ______________________________

Answer: ______________________________

9. What is the program which runs for the longest time and screens at 8:00 pm?

Plan: ______________________________

Answer: ______________________________

10. Which channel has the most highest rating programs and how many are there?

Plan: ______________________________

Answer: ______________________________

11. Which country produces the most highest rating 60 minute programs?

Plan: ______________________________

Answer: ______________________________

12. Which channel has the most 30 minute programs?

Plan: ______________________________

Answer: ______________________________

13. Write your own question which involves at least a secondary field.

Question: ______________________________

Plan: ______________________________

Answer: ______________________________

The way to DEAL with problems is to:

1. Define the problem.

What are we trying to do here?
Can I restate the problem in my own words?
What do we know about the problem so far?
What information has been given to us?
What are the database categories and what do they mean?
What are the hypotheses we wish to test?

2. Explore alternative approaches.

What is our plan?
Is there another way to do this?
What would happen if ... ?
What should we do next?

3. Act on a Plan.

Are we using our plan or strategy?
Do we need a new plan?
Do we need a new strategy?

Has our goal changed?
What is our goal now?

Are we on the right track?
Are we getting closer to our goal?

4. Look at the effects.

What worked and what didn't?
What would we do differently next time?

Lesson 9

Objective:

By the end of the lesson the students should:

- have completed Testing Instrument Four.

Materials:

Testing Instrument Four booklets and answer sheets

Preparation:

Presentation:

1. Administer Testing Instrument Four

SELECTING RECORDS (FIND)

Lessons 10 & 11

Objective:

By the end of the unit students should:

- be able to use the FIND command to do single OR multiple selection searches.
- be able to SORT selected records.
- be able to use the FIND command to display all those records which do not meet the selection criteria (OMIT).
- be developing skills that enable them to plan, check, and evaluate problems.

Materials:

One computer with overhead screen for demonstration purposes
Student FIND worksheet

Preparation:

Photocopy class set of FIND worksheet.
Have student database on a computer that can be used for demonstration.

Presentation: (It is expected that this topic will run over two lessons.)

1. The teacher will first need to demonstrate the various functions to the class and then allow them to complete the worksheet. It is important for teachers to model correct and successful strategies for their students.

   The FIND option allows you to FIND, SEPARATE OR COUNT specific pieces of information from the database.

   This is achieved by typing a word (or letter or number) you wish to find into the particular empty field box on the find screen. Upon request the data base management program will then find all the records that contain that word, letter, or number. You may also use comparison operators if the field contains numbers, dates or times. Comparison operators used are as follows:

=	equal to		
>	greater than	<	less than
>=	greater than or equal to	<=	less than or equal to

2. **Single selection searches**

   - Open students Database
   - Choose FIND in the LAYOUT menu
   - Type F in the sex field
   - All the females are listed. The status window shows how many records have been selected e.g. 10 out of 23
   - Now SORT them alphabetically by surname and first name.

At any time all the records can be made visible again by choosing SHOW ALL RECORDS from the ORGANISE menu.

3. Multiple selection searches

You can enter requests into more than one field in the FIND screen.
If you enter data into two fields this sets up a logical **AND** condition.
That is, the selected or found records must meet BOTH criteria, i.e. one AND the other.

e.g. Select FIND
- in the sex field enter F
- in the hair colour enter Blonde
- Return

Notice all the selected records are female AND blonde

Other times you may want to set up a logical **OR** condition. That is the selected records need only meet one OR the other criteria.

This is achieved by entering one find field request normally, then for the second request choose EDIT menu, then NEW REQUEST.

e.g. Select FIND
- in the sex field enter F
- then use the Edit menu to select NEW REQUEST
- a second box will appear - in the hair colour field type Blonde
- Return

Notice all the selected records are female OR blonde.

TWO CHOICES WITH MULTIPLE SELECTION SEARCHES

AND	OR
(enter selections in one request)	(enter the selections in separate requests)

4. Omitting records

This is an option that allows you to find or display all the records which DO NOT match your selection. Just click on the OMIT box in the status window to the left of the screen after entering your selection.

e.g. Let us select all those students who are NOT blonde.
Choose FIND, enter blonde in hair colour field, click on the OMIT box then Return.

All the records displayed are NOT blonde.

5. Refining search requests

At times you may wish to refine a selection search. If you had selected all the boys with blonde hair and now only wanted those that were born after 1/6/79, you would use a single search and place > 1/6/79 in the birthdate box and select visible. This will only search those records that have already been selected and therefore further refine your initial search.

Model the example for the students and then ask them to complete the Find worksheet. First students should plan their FIND requests on paper using the worksheet and then they should carry out these requests on the computer.
Remind them that good problem solvers DEAL with their problems. Encourage them to work in groups but record individual answers.
Debrief the class by going over the answers as a class group.

FIND WORKSHEET

NAME:__________________________

Write out the **FIND** requests you could use to answer these questions. There may be more than one way to do them. Don't forget to consider whether sorting after you have found your records will be of help.

Remember good problem solvers DEAL with their problems.

Tick your options for each search. Write down the operators you would use in the appropriate boxes, and then after performing the search on the computer write down the answer. If you feel that a particular answer is incorrect and that a search you planned does not work, neatly cross out the old search and write in a new search beside it.

EXAMPLE:
How many students have t in their surname?

OR ☐ **AND** ☐ **SORT** ☐

Surname	Given Name	Sex	Hair	Birthdate
t				

Answer: ______________________________

1. How many students have t in their first name?

OR ☐ **AND** ☐ **SORT** ☐

Surname	Given Name	Sex	Hair	Birthdate

Answer: ______________________________

2. How many students have t in their surname AND first name?

OR ☐ **AND** ☐ **SORT** ☐

Surname	Given Name	Sex	Hair	Birthdate

Answer: ______________________________

3. How many students have t in either their surname OR firstname?

OR ☐ **AND** ☐ **SORT** ☐

Surname	Given Name	Sex	Hair	Birthdate

Answer: ______________________________

4. How many students have blonde hair?

OR ☐ **AND** ☐ **SORT** ☐

Surname	Given Name	Sex	Hair	Birthdate

Answer: ______________________________

5. How many students have Black hair or are female?

OR ☐ **AND** ☐ **SORT** ☐

Surname	Given Name	Sex	Hair	Birthdate

Answer: ______________________________

6. What is the latest birthdate in 1978?

OR ☐ **AND** ☐ **SORT** ☐

Surname	Given Name	Sex	Hair	Birthdate

Answer: ______________________________

7. Find the oldest blonde student?

OR AND SORT

☐ ☐ ☐

Surname	Given Name	Sex	Hair	Birthdate

Answer: ____

8. How many males have birthdates later than July 1978?

OR AND SORT

☐ ☐ ☐

Surname	Given Name	Sex	Hair	Birthdate

Answer: ____

9. How many female students have brown hair? Write down their initials.

OR AND SORT

☐ ☐ ☐

Surname	Given Name	Sex	Hair	Birthdate

Answer: ____

10. How many students born after August 1978 have blonde hair? Write down their initials.

OR AND SORT

☐ ☐ ☐

Surname	Given Name	Sex	Hair	Birthdate

Answer: ____

11. How many female students born before September 1978 and have brown hair ?

OR AND SORT

Surname	Given Name	Sex	Hair	Birthdate

Answer: ______________________________

12. How many students with an "a" in their surname and first name and have blonde hair? Write down their initials.

OR AND SORT

Surname	Given Name	Sex	Hair	Birthdate

Answer: ______________________________

13. How many students have birthdates in 1978?

OR AND SORT

Surname	Given Name	Sex	Hair	Birthdate

Answer: ______________________________

14. How many students were born in the first 6 months of 1978?

OR AND SORT

Surname	Given Name	Sex	Hair	Birthdate

Answer: ______________________________

SELECTING RECORDS (FIND AND SORT)

Lessons 12 & 13

Objective:

By the end of the unit students should:

- become fluent at using the Find and / or Sort features of ClarisWorks to answer a variety of questions.
- continue to use the DEAL strategy to solve problems.

Materials:

A copy of the High School database on each computer
Enough computers for one per group
A class set of the Find/Sort worksheet
The DEAL strategy prompt sheet

Presentation:

1. Explain to students that the database they are going to work with contains information on fictional student backgrounds and the number of police contacts they have had.

2. Introduce the students to the database by going over the categories in the database with them.

3. Revise with the students the different ways of using the find command.

4. Do the first question on the worksheet as an example for the students. Remember to model the DEAL strategy as you complete the question.

5. Instruct the students to work in groups to fill out the worksheet before they use the computer. Remind them to DEAL with their problem.

6. Once all selection criteria have been entered allow the students to try out their selections on the computer. If students make a mistake and their plan does not work instruct them to neatly cross out their mistake and write a new plan next to the old.

7. Debrief class on worksheet, discussing findings, problems and alternative methods.

FIND AND SORT WORKSHEET

NAME:______________________

The database to use for this worksheet is under the heading of "High School". Open this database, it contains student data on Students' backgrounds and the number of police contacts they have had.

Answer the following questions by first ticking the appropriate boxes and writing the selection criteria you will use for each search.

Notice that you have to write the name of the fields that you are using on top of the find box. If you need to use more than one find box simply draw a line across the long box to divide it into several smaller boxes. After you have finished planning your search you can then work out the answers by using the computer.

Don't forget to DEAL with your problems. If your plan doesn't work neatly cross it out and write a new plan next to the old.

EXAMPLE:

How many boys are there in the school?

OR ☐ AND ☐ SORT ☐

	Sex	
Find Box	M	

Answer: ______________________

1. **How many girls are there in the school?**

OR ☐ AND ☐ SORT ☐

Find Box ______________________

Answer: ______________________

2. **How many students are in years 7 and 8?**

OR ☐ AND ☐ SORT ☐

Find Box ______________________

Answer: ______________________

3. What is the greatest family income?

OR ☐ AND ☐ SORT ☐

Find Box ____________________

Answer: ____________________

4. How many students have been suspended one or more times?

OR ☐ AND ☐ SORT ☐

Find Box ____________________

Answer: ____________________

5. How many students have had 1 police contact and have not been suspended?

OR ☐ AND ☐ SORT ☐

Find Box ____________________

Answer: ____________________

6. How many students have had 1 police contact and have been suspended one or more times?

OR ☐ AND ☐ SORT ☐

Find Box ____________________

Answer: ____________________

7. How many students are 13 or 14?

OR AND SORT

☐ ☐ ☐

Find Box

Answer: ____________________

8. How many students have been suspended 3 or more times?

OR AND SORT

☐ ☐ ☐

Find Box

Answer: ____________________

9. How many families have incomes over $24,000?

OR AND SORT

☐ ☐ ☐

Find Box

Answer: ____________________

10. Who is the oldest girl in the school?

OR AND SORT

☐ ☐ ☐

Find Box

Answer: ____________________

11. What is the highest salary amongst the divorced parents of the students?

OR AND SORT

☐ ☐ ☐

Find Box ______________________

Answer: ______________________

12. How many students with divorced parents have had 1 or more police contacts?

OR AND SORT

☐ ☐ ☐

Find Box ______________________

Answer: ______________________

HYPOTHESIS TESTING

Lessons 14 & 15

Objective:

By the end of the unit students should be able to:

- Define hypothesis
- Construct various hypotheses for given databases
- Design and carry out a search to test hypotheses

Materials:

A copy of the High School database on each computer
Enough computers for one per group
A class set of the High School Hypothesis testing worksheet.

Presentation:

1. It is very important to commence each of the hypothesis testing sections with a concept formation discussion in which students are encouraged to start thinking in the area and drawing together their existing knowledge. This lesson therefore needs to start with a concept formation discussion about police contacts. Discuss with class those factors that may have an influence on a person coming into contact with the police. Emphasise that police contacts may not necessarily be a bad thing. Narrow down discussion to include more negative contacts with police.

2. Define Hypothesis: One way to try and answer a question is to guess what the answer might be and then try and verify whether the guess is accurate. This is called a hypothesis. It is an educated guess. Outline where hypothesis formation and testing fits within the DEAL strategy. Give an example.

3. Direct students to the High School Database they have been working with. One way to further define the problem is to form a hypothesis and then test it. Direct them to formulate a hypothesis about Police Contacts. i.e. Get students to have an educated guess at the question. What is an important factor that has a relationship to the number of police contacts that a student has? Direct students to write out their guess (hypothesis) in the space provided on the worksheet. At this stage it is important that students construct hypotheses that contain only one other category apart from police contacts. If students construct a hypothesis that contains more than one category ask them to simplify their hypothesis.

4. Designing a search to test hypothesis.

   One plan that may help us test some hypotheses is to **Divide and Check.**

   Go over the divide and check method for testing hypotheses.

   - Check and become familiar with the database categories.
   - Formulate a hypothesis about the data.
   - Arrange the data in a meaningful way.
   - Sort and Divide into three sections.
   - Compare the top and bottom sections and check if the data supports your hypothesis.
   - Make a decision about your hypothesis.

It is important that students understand that they are not proving whether a particular hypothesis is true but rather if the data does or does not support the hypothesis.

5. Get students to plan a search for their hypothesis on the worksheet.

6. After they have planned a search the students can act on their plan and search the database in order to determine if they are to accept or reject their hypothesis.

7. Repeat the above procedure until students have used the DEAL strategy to test three hypotheses.

8. A very important stage in the hypothesis testing lessons is to debrief the students on the subject area they have been working on. To do this get each of the groups to report the results of their group testing and allow the class to discuss and review the findings. Because hypothesis testing involves the interpretation of information you will find that students at times will disagree on some issues. Encourage interaction between class members and remember that consensus is not always necessary.

HYPOTHESIS TESTING

Lesson 16

Objective:

By the end of the unit students should be able to:

- Construct various hypotheses for given databases.
- Design and carry out a search to test hypotheses.

Materials:

A copy of the High School database on each computer
Enough computers for one per group
A class set of the High School Hypothesis testing worksheet.

Presentation:

1. Lead the class in a concept formation discussion about school suspensions. Discuss with class those factors that may have an influence on a person being suspended from school.

2. Direct students to the High School Database they have been working with. Direct them to use the DEAL strategy to test the factors that influence and are related to school suspensions.

3. Remind them of the divide and check method for testing hypotheses.

    - Check and become familiar with the database categories.
    - Formulate a hypothesis about the data.
    - Arrange the data in a meaningful way.
    - Sort and Divide into three sections.
    - Check if the data supports your hypothesis.
    - Make a decision about your hypothesis.

    It is important that students understand that they are not proving whether a particular hypothesis is true but rather if the data does or does not support the hypothesis.

4. Students should test three hypotheses about school suspensions.

5. Debrief the class as you lead out in a discussion of the results of their hypothesis testing.

6. Administer Multiple Choice Quiz on the High School database.

HIGH SCHOOL HYPOTHESIS TESTING WORKSHEET

NAME:______________________________

Use the DEAL strategy to test four hypotheses about suspensions.

Hypothesis One:

1. **Define the Problem.**
What is the hypothesis that we wish to test? ____________________________

____

2. **Explore Alternative Approaches.**
What categories do we wish to include?______________________________

____

What is the plan for the search strategy? ____________________________

____

3. **Act on a Plan.**
What are the results of the search? ______________________________

____

Has our goal been reached? ______________________________________

4. **Look at the effects**
Will you accept or reject the hypothesis? ____________________________

Hypothesis Two:

1. **Define the Problem.**
What is the hypothesis that we wish to test? ____________________________

____

2. **Explore Alternative Approaches.**
What categories do we wish to include?______________________________

____

What is the plan for the search strategy? ____________________________

____

3. **Act on a Plan.**
What are the results of the search? ______________________________

____

Has our goal been reached? ______________________________________

4. **Look at the effects**
Will you accept or reject the hypothesis? ____________________________

Hypothesis Three:

1. **Define the Problem.**
   What is the hypothesis that we wish to test? ______________________________

   ____

2. **Explore Alternative Approaches.**
   What categories do we wish to include? ______________________________

   ____

   What is the plan for the search strategy? ______________________________

   ____

3. **Act on a Plan.**
   What are the results of the search? ______________________________

   ____

   Has our goal been reached? ______________________________

4. **Look at the effects**
   Will you accept or reject the hypothesis? ______________________________

Hypothesis Four:

1. **Define the Problem.**
   What is the hypothesis that we wish to test? ______________________________

   ____

2. **Explore Alternative Approaches.**
   What categories do we wish to include? ______________________________

   ____

   What is the plan for the search strategy? ______________________________

   ____

3. **Act on a Plan.**
   What are the results of the search? ______________________________

   ____

   Has our goal been reached? ______________________________

4. **Look at the effects**
   Will you accept or reject the hypothesis? ______________________________

WORLD DATABASE HYPOTHESIS TESTING

Lessons 17 & 18

Objective:

By the end of the unit the students should be able to:

- Construct various hypotheses for the World database.
- Design and carry out a search to test hypotheses.

Materials

A copy of the World database on each computer
Enough computers for one per group
A class set of the World database category headings worksheet
A class set of the World Hypothesis testing worksheet

Presentation:

1. Lead out in a discussion that will serve as a concept formation exercise about countries of the world and life expectancy. Ask students in which countries do they think people live the longest? Which countries have the shortest life expectancy? What factors do they think will have an impact on life expectancy?

2. Introduce students to the World Database. Hand out categories worksheet and familiarise students with the categories of the database by directing them to write the appropriate explanations for each of the categories in the spaces provided on the worksheet.

3. Direct students to investigate life expectancy in countries of the world using the DEAL strategy. From the categories of the database have the students construct four hypotheses about factors that affect life expectancy. These should be filled in on the hypothesis testing worksheet provided.

4. Students should then complete the worksheet up to the Act on the plan section for each of the hypotheses.

5. Using their plan students should then test each of their hypotheses in turn using the computer and hence complete the worksheet. It is important that students understand that they are not proving whether a particular hypothesis is true but rather if the data does or does not support the hypothesis.

6. Debrief the class as you lead out in a class discussion of the results of their hypothesis testing.

World Database Categories

Write in the space provided an explanation of each of the categories in the World Database.

Region ____

Country ____

Life ____

Infant ____

Population ____

Daily ____

Primary ____

Secondary ____

Population ____

Pop. Growth ____

Urban ____

GNP ____

GNP Growth ____

Agricultural ____

Energy ____

Exports ____

Public Debt ____

World Database Categories

Region	Global Area
Country	Country's Name
Life	Life Expectancy at Birth (years)
Infant	Infant Mortality (per 1000 live births)
Population	Population per Physician
Daily	Daily Calorie supply per capita
Primary	Total primary enrolments as a percentage of the primary age population
Secondary	Total secondary enrolments as a percentage of the secondary age population
Population	Population in millions
Pop. Growth	Average annual population growth rate (percent)
Urban	Urban population as a percentage of total population
GNP	GNP per capita (US dollars)
GNP Growth	Annual average growth of GNP per capita (percent)
Agricultural	Percentage of the work force in Agriculture
Energy	Energy consumption (kgs of oil)
Exports	Merchandise Exports in Millions of US dollars
Public Debt	Total public debt as a percentage of GNP

WORLD DATABASE HYPOTHESIS TESTING WORKSHEET

NAME:________________________

Use the DEAL strategy to test four hypotheses about life expectancy.

Hypothesis One:

1. **Define the Problem.**
   What is the hypothesis that we wish to test? ________________________

   ____

2. **Explore Alternative Approaches.**
   What categories do we wish to include?________________________

   ____

   What is the plan for the search strategy? ________________________

   ____

3. **Act on a Plan.**
   What are the results of the search? ________________________

   ____

   Has our goal been reached? ________________________

4. **Look at the effects**
   Will you accept or reject the hypothesis? ________________________

Hypothesis Two:

1. **Define the Problem.**
   What is the hypothesis that we wish to test? ________________________

   ____

2. **Explore Alternative Approaches.**
   What categories do we wish to include?________________________

   ____

   What is the plan for the search strategy? ________________________

   ____

3. **Act on a Plan.**
   What are the results of the search? ________________________

   ____

   Has our goal been reached? ________________________

4. **Look at the effects**
   Will you accept or reject the hypothesis? ________________________

Hypothesis Three:

1. **Define the Problem.**
   What is the hypothesis that we wish to test? ______________________________

   ____

2. **Explore Alternative Approaches.**
   What categories do we wish to include? ______________________________

   ____

   What is the plan for the search strategy? ______________________________

   ____

3. **Act on a Plan.**
   What are the results of the search? ______________________________

   ____

   Has our goal been reached? ______________________________

4. **Look at the effects**
   Will you accept or reject the hypothesis? ______________________________

Hypothesis Four:

1. **Define the Problem.**
   What is the hypothesis that we wish to test? ______________________________

   ____

2. **Explore Alternative Approaches.**
   What categories do we wish to include? ______________________________

   ____

   What is the plan for the search strategy? ______________________________

   ____

3. **Act on a Plan.**
   What are the results of the search? ______________________________

   ____

   Has our goal been reached? ______________________________

4. **Look at the effects**
   Will you accept or reject the hypothesis? ______________________________

WORLD DATABASE HYPOTHESIS TESTING

Lessons 19 & 20

Objective:

By the end of the unit the students should be able to:

- Construct various hypotheses to be tested using the World database.
- Design and carry out a search to test hypotheses

Materials:

A copy of the World database on each computer
Enough computers for one per group
A class set of the World database category headings worksheet
A class set of the World Hypothesis testing worksheet

Presentation:

1. Lead out in a class discussion that will serve as a concept formation exercise about various economies of the countries of the world.

2. Direct students to use the DEAL strategy to investigate economies of the world. It is preferred that they work in groups to determine relevant economic hypothesis to test. eg.
   What type of countries are the economically strongest?
   What is the relationship between energy use and economic wealth?
   What countries are growing the fastest? Why?

3. From the categories of the database, have the students construct four hypotheses linking factors that affect countries' economies. These should be filled in on the hypothesis testing worksheet provided.

4. Students should then complete the worksheet up to the Act on the Plan section for each of the hypotheses.

5. Using their plan students should then test each of their hypotheses in turn and hence complete the worksheet.

6. Get students to select and substantiate from the database the country that they would choose to move to if they were forced to leave Australia.

7. Debrief with the entire class by discussing their hypotheses and the results of their searches. Also discuss the country they would move to and the reasons why.

8. Administer Multiple Choice Quiz on the World database.

WORLD DATABASE HYPOTHESIS TESTING WORKSHEET

NAME:____________________________

Use the DEAL strategy to test four hypotheses about countries' economies.

Hypothesis One:

1. **Define the Problem.**
   What is the hypothesis that we wish to test? ____________________________

   ____

2. **Explore Alternative Approaches.**
   What categories do we wish to include?______________________________

   ____

   What is the plan for the search strategy? ____________________________

   ____

3. **Act on a Plan.**
   What are the results of the search? ______________________________

   ____

   Has our goal been reached? ____________________________________

4. **Look at the effects**
   Will you accept or reject the hypothesis? ____________________________

Hypothesis Two:

1. **Define the Problem.**
   What is the hypothesis that we wish to test? ____________________________

   ____

2. **Explore Alternative Approaches.**
   What categories do we wish to include?______________________________

   ____

   What is the plan for the search strategy? ____________________________

   ____

3. **Act on a Plan.**
   What are the results of the search? ______________________________

   ____

   Has our goal been reached? ____________________________________

4. **Look at the effects**
   Will you accept or reject the hypothesis? ____________________________

Hypothesis Three:

1. **Define the Problem.**
   What is the hypothesis that we wish to test? ______________________

   ____

2. **Explore Alternative Approaches.**
   What categories do we wish to include?______________________

   ____

   What is the plan for the search strategy? ______________________

   ____

3. **Act on a Plan.**
   What are the results of the search? ______________________

   ____

   Has our goal been reached? ______________________

4. **Look at the effects**
   Will you accept or reject the hypothesis? ______________________

Hypothesis Four:

1. **Define the Problem.**
   What is the hypothesis that we wish to test? ______________________

   ____

2. **Explore Alternative Approaches.**
   What categories do we wish to include?______________________

   ____

   What is the plan for the search strategy? ______________________

   ____

3. **Act on a Plan.**
   What are the results of the search? ______________________

   ____

   Has our goal been reached? ______________________

4. **Look at the effects**
   Will you accept or reject the hypothesis? ______________________

MOVIE DATABASE HYPOTHESIS TESTING

Lesson 21

Objective:

By the end of the unit students should be able to:

- engage in concept formation in the area of movies

Materials:

Movie Discussion OHT.

Presentation:

1. This lesson serves as the introduction class to the topic of movies. The teacher can commence by making a few observations about the topic.

2. Divide the class up into groups and get them as a group to answer the questions on the movie worksheet. Members of the groups should write down their groups' answers.

3. Debrief the class by having the various groups report their answers back to the entire class.

Movies

1. List your top five favourite movies.
2. List the worst movie you have ever seen.
3. What are good and bad points about movies?
4. Think of a couple of movies and list their strengths and weaknesses.
5. List three things you think that movies are designed to do?
6. Prioritise the above.
7. Name the top movie that matches your priority listing.
8. What do you think movies should be designed to do?
9. If you had money to invest what type of movie would you invest in?
10. Have movies changed over the years?

Movies

1. Has a foreign language film ever been chosen as best film at the Academy Awards?

2. What factors would have to change for this to happen?

3. What characteristics would a foreign film have to have to be voted best picture?

4. Design the publicity campaign for a foreign language film.

MOVIE DATABASE HYPOTHESIS TESTING

Lessons 22 & 23

Objective:

By the end of the unit students should be able to:

- interrogate a database to obtain information necessary for the solution of some problems.

Materials:

Movie Database Categories Worksheet
Movie Questions Worksheet

Presentation:

1. Introduce students to the movie database. To help them become familiar with the database give out the categories worksheet and take students through the database categories by explaining them one by one. Students should then fill out the definition of the categories in the space provided.

2. Hand out Movie question sheet and direct groups to begin answering questions using the database. This worksheet requires a combination of various skills used to interrogate the database. Encourage the students to make use of the DEAL strategy as they attempt to answer the questions. This worksheet is one of the first times that students are asked to solve problems using the DEAL strategy without having a detailed worksheet to work with. Students will need assistance to structure their answers.

3. The question sheet will require students to work into the next period.

Movie Database Categories

Write in the space provided an explanation of each of the categories in the Movie Database.

Category ______________________________

Name ______________________________

Rating ______________________________

Director ______________________________

Cast ______________________________

Censor ______________________________

Year ______________________________

Colour ______________________________

Length ______________________________

Cost ______________________________

Earnings ______________________________

Plot ______________________________

Movie Database Categories

Category	Type of Movie: Western, Comedy, Horror etc...
Name	Name of Movie
Rating	Rating from 1 to 5 given by a film critic.
Director	Name of the film's Director
Cast	The main actors and actresses
Censor	The censorship rating: G, PG, M, R etc...
Year	The year the movie was made
Colour	Whether the film was black and white or colour
Length	The length of the film in minutes
Cost	The cost of production of the film
Earnings	The amount the film has earnt
Plot	A brief summary of the story of the movie

Movie Worksheet

Complete the following worksheet by writing all answers on a separate sheet of paper.

1. What are the various types of movies in the database ?
2. In how many movies has Mel Gibson starred?
3. Around what years did movies start making the transition from black and white to colour?
4. Of the movies listed how many were made in the 70's?
5. In what movie did Bob Hoskins star in 1988?
6. Who were some of the most popular stars of the 1980's?
7. In what year did censorship of films under the ratings of G, PG, M, and R commence?
8. What do you think are the main things that are necessary for a movie to be financially successful?
9. What has been the most popular movie of all time?
10. Of the various categories included in the database which ones are the more important in communicating information about a particular movie? Write the categories out in order of importance.
11. Is there any relationship between the **earnings** and **ratings** categories of movies in the movie database?
12. If you were to invest money in a movie now, what type of movie would it be ?

MOVIE DATABASE

Lesson 24

Objective:

By the end of the unit students should be able to:

- interrogate a database to obtain information necessary for the solution of some problems.

Materials:

Movie Database Categories Worksheet
Movie Questions Worksheet

Presentation:

1. Lead class in a debriefing discussion of the movie database by examining the answers that various groups obtained to the movie database question sheet. Ask students to explain how they followed the DEAL strategy to solve problems and answer the questions.

2. Answer the Multiple Choice Quiz on the Movie database.

BUILDING A DATABASE

Lessons 25 & 26

Objective:

By the end of the unit students should be able to:

- design and interrogate a database.

Materials:

Building a Database Worksheets

Presentation:

1. Students are introduced to the idea that not only can they work with databases that have already been prepared but they can also work with a database that they have built themselves.

2. Have every student in the class fill out the building a database worksheet.

3. Photocopy the completed worksheets so that there are two copies in the room.

4. Students work on the computers and create a new database from scratch using the categories/fields on the sheets.

5. Students then type in each of the class records into the database.

6. If students are too slow at data entry they can work in groups and then merge their entries.

Year Nine Favourites

Fill in the card below by listing your favourites for each field.

Name: ______________________________

Musical Group: ______________________________

Musical Instrument: ______________________________

Singer: ______________________________

Song: ______________________________

Chosen Career: ______________________________

Fast Food Restaurant: ______________________________

Sport to play: ______________________________

Sport to watch: ______________________________

School Subject (favourite): ______________________________

School Subject (least favourite): ______________________________

TV program: ______________________________

Movie: ______________________________

Actor/Actress: ______________________________

Holiday: ______________________________

Hobby: ______________________________

BUILDING A DATABASE

Lessons 27 & 28

Objective:

By the end of the unit the students should be able to:

- form hypotheses from the student database that they have compiled.

Materials:

OHT of categories.

Presentation:

1. Split class into groups and get them to brainstorm using the DEAL strategy to come up with five hypothesis that they can test using the class database they have built. Ask students to have the DEAL strategy sheet on the desk as they consider their hypotheses and how they plan to test them.

   Use the OHT of categories and model the formation of one hypothesis before the class.

2. Have each group report back to the class one hypothesis they are going to test, and how they are going to test it.

   Some suggested hypotheses may be:

   - Most students favourite musical group has had a hit during the last few years.
   - Most students in year 9 hope to pursue a professional career.
   - Most students prefer to play a different sport than what they watch.
   - Most students have a favourite holiday that is within Australia.
   - Most students prefer to eat at MacDonalds for fast food.

3. The class should then return to the computers and test their hypotheses.

4. Lead out in a debriefing discussion about the class and their favourites. Have groups report back the results of their hypothesis testing.

Year Nine Database Fields

Name

Musical Group

Musical Instrument

Singer

Song

Chosen Career

Fast Food Restaurant

Sport to play

Sport to watch

School Subject (favourite)

School Subject (least favourite)

TV program

Movie

Actor/Actress

Holiday

Hobby

CREATING A DATABASE

Lessons 29 to 37

Objective:

By the end of the unit the students should be able to:

- Select a subject area they wish to research.
- Compile research questions they wish to answer.
- Plan what fields are needed in a database to assist in collecting information to answer the research questions above.
- Collect data to be entered into a database.
- Compile a database.
- Answer research questions by testing various hypotheses.
- Write a report on the above project.

Materials:

Class computers

Presentation:

1. Split students into groups that are going to work together to construct a database. Ask them to select a subject area that they are interested in investigating. Direct them to use the DEAL strategy in their investigation.

2. After some preliminary discussion in which they define the problem they wish to work on, each group should formalise their work by putting together a proposal in which they detail:

- Subject of the database they are going to construct.
- Research questions that they are going to attempt to answer.
- What fields do they plan to store their data in.
- How do they plan to collect the data?
- Each group should gain teacher clearance before they proceed past this point.

3. Groups are to collect data to be entered into a database.

4. Groups are to interrogate their database and test hypotheses and answer research questions.

5. Students are to write a report on the above project. This report is to be submitted for assessment.

Project Suggestions:

Computer Games
Breakfast cereal contents
Camping Gear
Songs and Music
Staff favourites
Sports

Lesson 38

Objective:

By the end of the lesson the students should have:

- completed Testing Instrument Six.

Materials:

Testing Instrument Six booklets and Answer Sheets

Preparation:

Presentation:

1. Administer Testing Instrument Six.

Lesson 39

Objective:

By the end of the lesson the students should have:

- completed Testing Instrument Seven.

Materials:

Testing Instrument Seven booklets and Answer Sheets

Preparation:

Presentation:

1. Administer Testing Instrument Seven.

Lesson 40

Objective:

By the end of the lesson the students should have:

- completed Testing Instrument Eight.

Materials:

Testing Instrument Eight booklets and Answer Sheets

Preparation:

Presentation:

1. Administer Testing Instrument Eight.

Appendix 1.2 Databases used in the Course

During the database course the students work with a number of databases. Appendix 1.2 considers each database in turn and details the categories found in each database, provides an example of a record from each database, and lists all of the records in each database.

Appendix 1.2.1 TV Database

The TV database is used in Lesson 2 and contains records of 40 television shows. Each record contains information in six categories that are described in Table A1.2. The students in the various classes provide the data for this database.

Table A1.2 Categories in the TV Database

NAME:	Name of the TV program.
CHANNEL:	Channel on which the program is screened.
SCREENING TIME:	Time the program is screened.
LENGTH:	The number of minutes the program runs for.
COUNTRY of origin:	The country in which the program was made.
RATING (1 to 5 stars)	The rating of the program by the student.

Figure A1.1 contains an example of a record from the TV database for the show Sports Sunday.

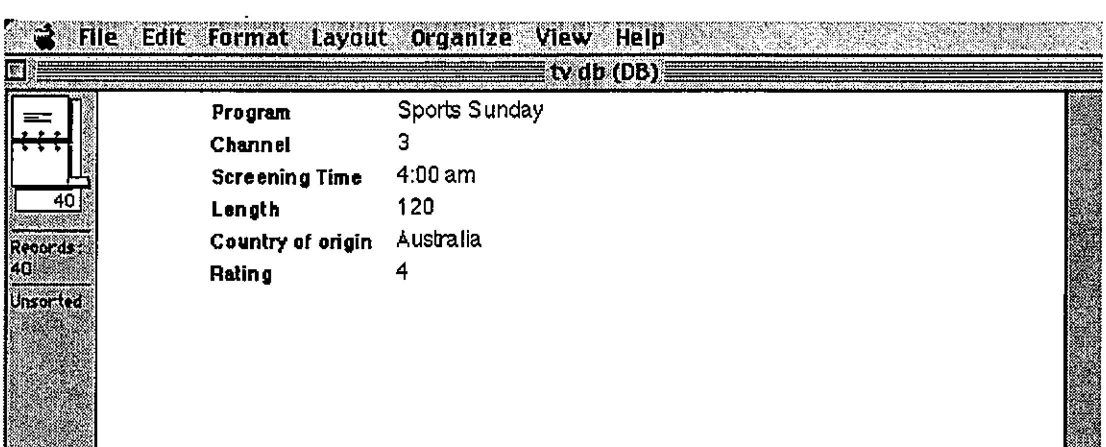

Figure A1.1 Example of a record in TV database

Table A1.3 Records in the TV database

Programs in TV database compiled by one of the class groups in the study.	
Paradise Beach	Gumby
Sex the Series	Home Improvement
Simpons	Late Show
Beverley Hills 90210	Ren & Stimpy
Mr Bean	Married With Children
Dr Quinn	Northern Exposure
Step by Step	Cricket
Country Practise	Mulligrubs
Basketball	Fast Forward
Home and Away	Talk to the Animals
Vidiot	Play School
Sesame Street	Bewitched
Parker Lewis can't Loose	Chip 'n' Dale
My Two Dads	Neighbours
Full House	Only Fools and Horses
Chipmunks	Quantum
Better Sex Quide	Hail and Pace
Ren and Stimpy	X-Men
Step by Step	Hey Dad
Altogether Now	Sports Sunday

Appendix A1.2.2 High School Database

The High School database is introduced in Lesson 14 and is the first database used in the hypothesis testing section of the course. It contains 100 records of students in a fictious high school. Each record contains information in 11 categories as described in Table A1.4.

Table A1.4 Categories in the High School Database

First Name:	First name of the student
Surname:	Surname of the student
Year:	Year the student is in school
Sex:	The gender of the student
Age:	The age of the student
Suspensions:	The number of time the student has been suspended from school.
Police Contacts:	The number of times the student has been officially contacted by the police.
Income:	The family's income
Divorced Parents:	Whether the students parents are divorced.
No. In Family:	The number in the family
Total:	The total number of students from that family at the school.

Figure A1.2 contains an example of a record from the High School database for the student Toni Anderson.

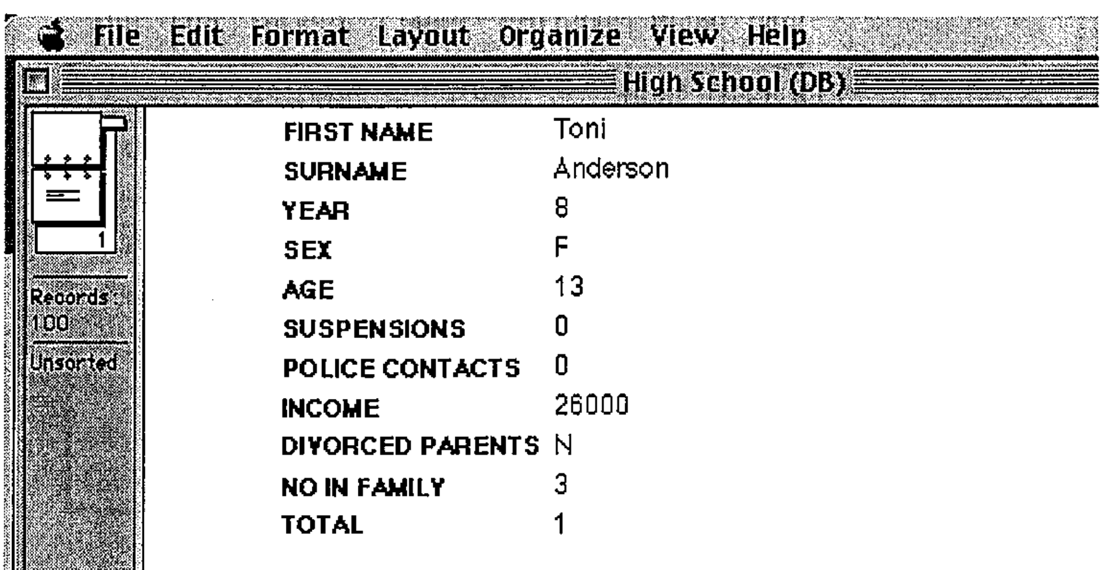

Figure A1.2 **Example of a record in High School database**

Table A1.5 The Students in the High School Database

Toni Anderson	Rebecca Barrett	Oswald Bingham
Natalie Brice	Peter Collins	Barry Couchman
Joanne Davidson	Paul Davis	Wes Deeps
Roslyn Dennis	Jack Desmond	Belinda Dobbs
Davis Faraday	Darryl Fogarty	Fred Ford
Rhonda Gallaway	Sarah Gillies	William Greeves
Gail Grossman	Lisa Gurtrude	Louise Helwig
Paula Henderson	Alison Hoiles	Pauline Hutton
Sid Jackson	Anthony Jacobs	Toni James
Linda Johnson	Angela Jones	Lilian Kambouris
Sally Kennett	Alan Kershaw	Gary Knott
Matthew Knowles	Sylvia Kuspod	Cathy Lindyman
Pheong Lolini	Kathryn Lombardi	Diane Long
Silvia Longley	Debra Lopez	Lynette Lowell
Linda Markewitz	Karen Marshall	Ian McKenzie
Susan Morphett	John Morris	David Moss
Rita Muller	Kathy Myers	Jennifer Naughton
Michael Nunn	Suzanne Oates	Sally O'Brien
Linda Olsen	Vinni Paolini	Stefan Pappas
Colleen Parker	Frank Roberts	Mart Rogan
John Rogevic	Fred Sampson	Stacey Sillance
Peta Slattery	Robert Sloan	Filbin Sloatino
Gloria Smart	Ferdinand Sotino	Michael Spadoni
Mario Spahtina	Gail Spalding	Carol Sparks
Tina Sparletti	Alan Spencer	Wayne Sporten
Margaret Stevenson	Angela Sweatman	Angela Swinden-Reece
Graeme Tansley	Terry Thewlis	Brian Thompson
Maria Togni	Grace Twinden	Susie Vickers
Monica Visser	Martin Watson	Kevin Watterson
John Wayne	Sharon Wellers	Steve Wendon
Greg West	Joe West	Bob Williams
Reg Wilson	Anthea Winter	Paul Witcombe
Stephanie Wyals	Slavko Yakov	Wilhela Zagorski
Gina Zlatkovic		

Appendix A1.2.3 World Database

The World database is introduced in Lesson 17 and contains the records of 129 countries from around the world. Each record contains information in 17 categories as described in Table A1.6.

Table A1.6 World Database Categories

Region	Global Area
Country	Country's Name
Life Expectancy	Life Expectancy at Birth (years)
Infant Mortality	Infant Mortality (per 1000 live births)
Population per Physician	Population per Physician
Daily Calories	Daily Calorie supply per capita
Primary school enrollment	Total primary enrollments as a percentage of the primary age population.
Secondary school enrollment	Total secondary enrollments as a percentage of the secondary age population.
Population	Population in millions
Population Growth	Average annual population growth rate (percent)
Urban	Urban population as a percentage of total population
GNP	GNP per capita (US dollars)
GNP Growth	Annual average growth of GNP per capita (percent)
Agricultural work force	Percentage of the work force in Agriculture.
Energy	Energy consumption (kgs of oil)
Exports	Merchandise Exports in Millions of US dollars.
Public Debt	Total public debt as a percentage of GNP.

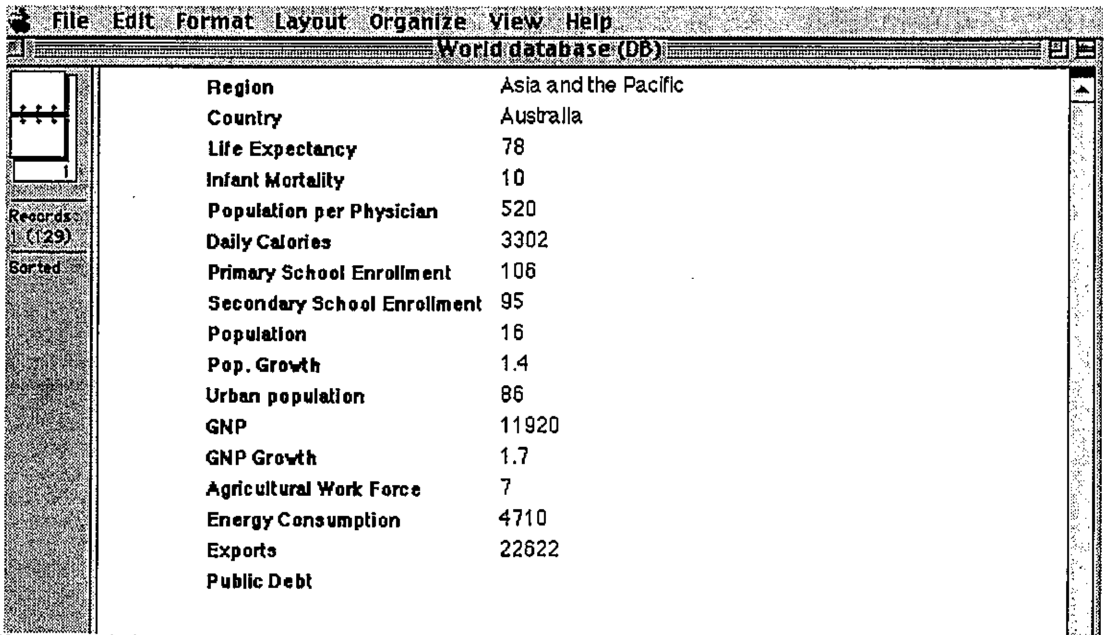

Figure A1.3 Example of a record in World database

Table A1.7 Countries included in World database

Afghanistan	Albania	Algeria	Angola
Argentina	Australia	Austria	Bangladesh
Belgium	Benin	Bhutan	Bolivia
Botswana	Brazil	Bulgaria	Burkina Faso
Burma	Burundi	Cameroon	Canada
Central African Rep.	Chad	Chile	China
Colombia	Congo	Costa Rica	Cote d'lvoire
Cuba	Czechoslovakia	Denmark	Dominican Rep.
Ecuador	Egypt, Arab Rep.	El Salvador	Ethiopia
Finland	France	Gabon	German Dem. Rep.
Germany Fed. Rep.	Ghana	Greece	Guatemala
Guinea	Haiti	Honduras	Hong Kong
Hungary	India	Indonesia	Iran, Islamic Rep.
Iraq	Ireland	Israel	Italy
Jamaica	Japan	Jordan	Kampuchea, Dem.
Kenya	Korea, Dem. Rep.	Korea, Rep. of.	Kuwait
Lao PDR	Lebanon	Lesotho	Liberia
Libya	Madagascar	Malawi	Malaysia
Mali	Mauritania	Mauritius	Mexico
Mongolia	Morocco	Mozambique	Nepal
Netherlands	New Zealand	Nicaragua	Niger
Nigeria	Norway	Oman	Pakistan
Panama	Papua New Guinea	Paraguay	Peru
Philippines	Poland	Portugal	Romania
Rwanda	Saudi Arabia	Senegal	Sierra Leone
Singapore	Somalia	South Africa	Spain
Sri Lanka	Sudan	Sweden	Switzerland
Syrian Arab Rep.	Tanzania	Thailand	Togo
Trinidad and Tobago	Tunisia	Turkey	Uganda
United Arab Emirates	United Kingdom	United States	Uruguay
USSR	Venezuela	Viet Nam	Yemen Arab Rep.
Yemen, PDR	Yugoslavia	Zaire	Zambia
Zimbabwe			

Appendix A1.2.4 Movie Database

Movie Database is introduced in Lesson 21 and contains the records of 204 movies from the years 1915 to 1992. Each record contains information in 12 categories as described in Table A1.8.

Table A1.8 Movie Database Categories

Category	The type of Movie.
Name	The name of the movie.
Rating	The rating given by a film critic.
Director	The director of the movie.
Cast	The main cast members in the movie.
Censor	The rating given the movie by the censor.
Year	The year the movie was released.
Colour	Whether the movie was in black and white or colour.
Length	The length of the movie in minutes.
Cost	The cost of producing the movie.
Earnings	The amount the movie has earned.
Plot	A summary of the story of the movie.

Figure A1.4 contains an example of a record from the Movie database for the movie Alien.

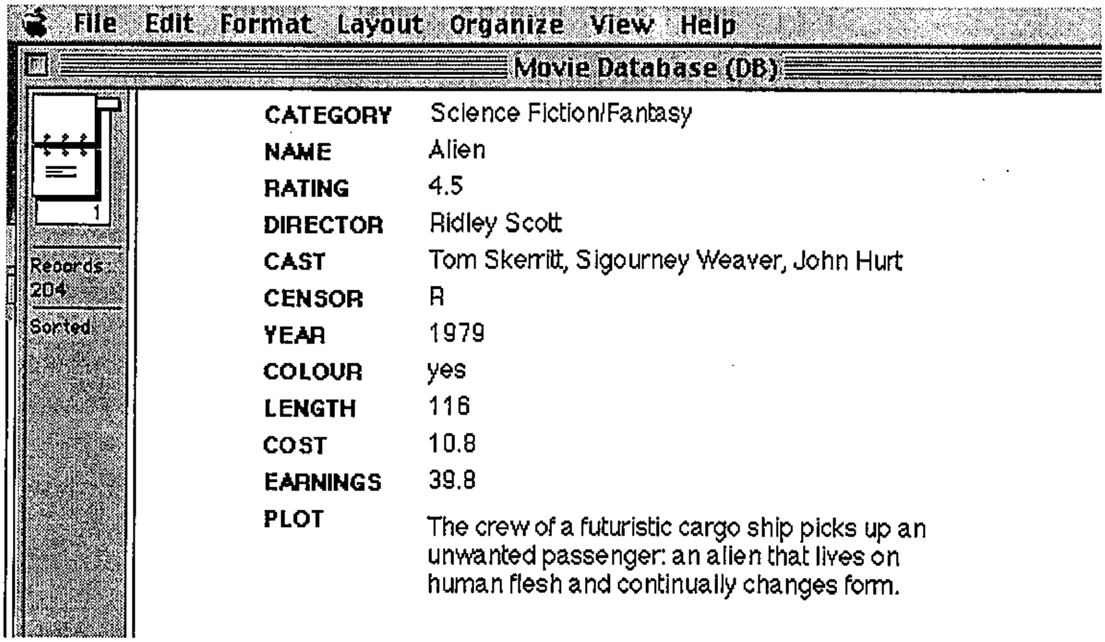

Figure A1.4 **Example of a record in Movie database**

Table A1.9 Movies included in the Movie Database

1941	Absence of Malice	Across the Pacific
Adventures of a Private Eye	Air America	Alfie
Alice's Restaurant	Alien	All Quiet on the Western Front
All the President's Men	An American Aristocracy	Anatasia
And Now for Something Completely Different	Any Which Way You Can	Arsenic and old Lace
Arthur	Auntie Mame	Avanlanche
Awakenings	Batman	Battle Cry
Battle of Britain	Ben Hur	Ben-Hur
Beyond the Poseidon Adventure	Billy Jack	Bird on a Wire
Blade Runner	Blazing Saddles	Bonnie and Clyde
Boulevard Nights	Bringing Up Baby	Bullitt
Bunco	Cabin in the Sky	Caddie
Cadillac Man	Camelot	Captains Courageous
Chariots of Fire	City Girl	Close Encounters of the Third Kind
Cobra	Cocoon	Color Purple, The
Conan the Barbarian	Crocodile Dundee	Cry Freedom
Danny Boy	Dead Calm	Deliverance
Deliverance	Dog Day Afternoon	Dragnet
Dune	Dying Young	E.T. - The Extra-Terrestrial
Enforcer, The	Escape from Alcatraz	ET - The Extra-Terrestrial
Eureka 4.5	Every Which Way But Loose	Fail-Safe
Fatal Attraction	Fate	Fear
Firefox	First Love	Flesh and the Devil
Frankie and Johnny	Ghost	Ghosts of Berkely Square
Giant	Gone with the Wind	Good Bye Girl, The
Goonies, The	Greed	Gremlins
Greystoke: The Legend of Tarzan, Lord of the Apes	Hamlet	He Said, She Said
Home Alone	Hooper	Hour of the Assassin
I Married a Monster from Outer Space	Ice Station Zebra	Invasion of the Body Snatchers
Kelly's Heroes	Keystone Comedies, Vol. 1	L.A. Story
Lassiter	Laura	Local Hero
Mad Max	Main Event, The	Memories of Me
Metropolis	Mister Roberts	Monty Python and the Holy Grail
Mortal Thoughts	Mr Mom	Naked Truth

Table A1.9 continued Movies included in the Movie Database

National Lampoon's European Vacation	National Lampoon's Vacation	Never Cry Wolf
Never Say Never Again	Night Caller from Outer Space	Nine to Five
No Time For Sergeants	Ocean's Eleven	Oh, God!
Picnic and Hanging Rock	Police Academy	Popi
Predator	Prehistoric Women	Pretty Woman
Private Benjamin	Project: Alien	Purple Rain
Quiet Thunder	Raiders of the Lost Ark	Rebecca
Rebel Rousers	Return of the Jedi	Revenge of the Nerds
Rio Bravo	Risky Business	Robin Hood - Prince of Thieves
Robocop	Romancing the Stone	Roxanne
Sabrina	Sahara	Sayonara
Sea Chase, The	Seance on a Wet Afternoon	Shining, The
Shirley Valentine	Shoot to Kill	Sink the Bismark
Sleeping with the Enemy	Smokey and the Bandit	Some Like it Hot
Son of Zorro Don Q	Sons of the Desert	Spies Like Us
Spifire	Star Is Born, A	Star Is Born, A
Star Wars	Steel Magnolias	Sudden Impact
Superman	Swing High, Swing Low	Tender Mercies
The Abyss	The Beautiful Blonde from Bashful Bend	The Belles of St. Trinian's
The Big Heat	The Big Mouth	The Big Parade
The Charge of the Light Brigade	The Clay Pigeon	The Clown
The Cops Blacksmith	The Count of Monte Cristo	The Day of the Jackal
The Day of the Triffids	The Deer Hunter	The Dirty Dozen
The Exorcist	The Flying Saucer	The Gambler and the Lady
The Getting of Wisdom	The Gunrunner	The Headless Horseman
The Importance of being Earnest	The Long Good Friday	The Never Ending Story
The Princess Bride	The Secret of My Success	The Spy Who Loved Me
The Sting	The Taming of the Shrew	The Thirty-Nine Steps
The War Game	The Woman in Red	The Year of Living Dangerously
Three Men and a little Lady	Tightrope	Tilt
Top Gun	Tora! Tora! Tora!	Towering Inferno, The
Turner and Hooch	Utu	Way Back Home
What's Up Doc?	Where Eagles Dare	Who Frmaed Roger Rabbit
Who's Afraid Of Virginia Woolf?	Woodstock	Young Einstein

Appendix A1.3 Database Software

During the study different schools had different database management software packages in their classrooms. As a consequence, the database course was adapted for each of the software platforms. While the databases developed for each software platform contained the same records, the way in which the students interacted with the databases was slightly different. In particular, the way in which students used the find and select functions differed across platforms. These differences are highlighted in the following sections that explain the way in which students find information in the Clarisworks (Macintosh), Microsoft Works 2 (IBM), and Microsoft Works 3 (IBM) databases.

Clarisworks

The FIND option in Clarisworks allows one to FIND specific pieces of information from the database. This is achieved by typing a word (or letter or number) you wish to find into the particular empty field box on the find screen. Upon request the data base management program will then find all the records that contain that word, letter, or number. You may also use comparison operators if the field contains numbers, dates or times. Comparison operators used are as follows:

=	equal to		
>	greater than	<	less than
>=	greater than or equal to	<=	less than or equal to

For example, in the illustrated example (Figure A1.5) a student wishing to find all the comedy movies made in 1980 would:

1. Open the Movie Database.
2. Choose FIND in the LAYOUT menu.
3. Type Comedy in the Category field.
4. Type 1980 in the Year field.
5. Click on the All button.

This sets up a logical **AND** condition where the selected or found records must meet BOTH criteria. Other times you may want to set up a logical **OR** condition. That is the selected records need only meet one OR the other criteria. This is achieved by entering one find field request normally, then for the second request choose EDIT menu, then NEW REQUEST.

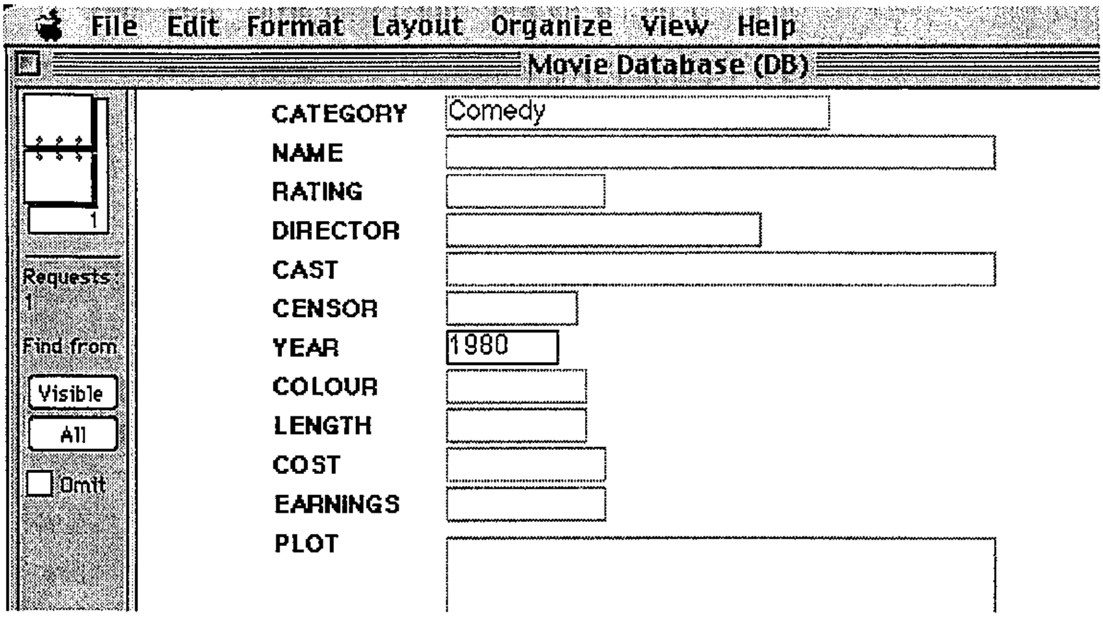

Figure A1.5 Clarisworks Find Request.

Microsoft Works 2 (IBM)

Using Microsoft Works 2, the **Query** option allows you to find specific pieces of information from the database. This is achieved by typing a word (or letter or number) you wish to find into the particular empty field box on the query screen. Upon request the data base management program will then find all the records that contain that word, letter, or number. You may also use comparison operators if the field contains numbers, dates or times. Comparison operators used are as follows:

=	equal to	<>	is not equal to
>	greater than	<	less than
>=	greater than or equal to	<=	less than or equal to

For example, in the illustrated example (Figure A1.6) a student wishing to find all the comedy movies made in 1980 would:

1. Open the Movie Database.
2. Choose Query in the View menu.
3. Type Comedy in the Category field.
4. Use the "&" connector and type year = "1980" in the Category field.
5. Select Apply Query.

This sets up a logical **AND** condition where the selected or found records must meet BOTH criteria. Other times you may want to set up a logical **OR** condition. That is the selected records need only meet one OR the other criteria. This is achieved by entering one query field request normally, then before you press enter, type a '|' followed by the second request which must be written in full if contains another field. This approach requires students to use more commands than Clarisworks and the students have to be familiar with the correct syntax.

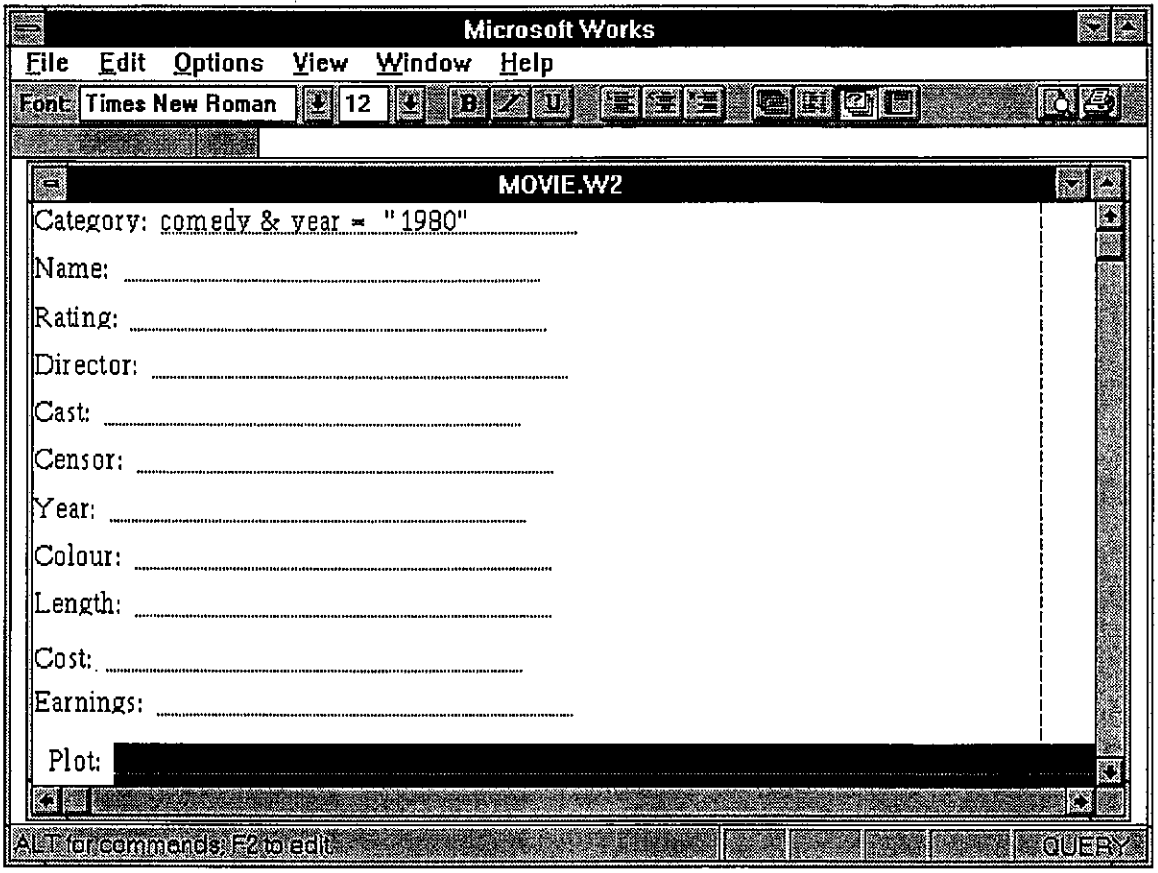

Figure A1.6 Microsoft Works 2 Query

Microsft Works 3 (IBM)

When using Microsoft Works 3 , as in Microsoft Works 2, the **Query** option allows you to find specific pieces of information from the database. This is achieved by creating query sentences. To do this click on the Tools menu and select **Create New Query**. A query sentence is made up of a field that is used to compare, a comparison operator, and a value to compare the field to. To create a query sentence select a field from the menu. (The menu becomes visible once you click on the down arrow button). Select a comparison operator from the menu, and finally type in a value to compare your selected field to. Comparison operators used are as follows:

is equal to
is less than
is greater than
is not equal to
is less than or equal to
is greater than or equal to
contains

When you have completed your query sentence click on the **Apply Now** button.

For example, in the illustrated example (Figure A1.7) a student wishing to find all the comedy movies made in 1980 would:

1. Open the Movie Database.
2. Choose Create New Query in the View menu.
3. Construct query sentence 1 with category is equal to Comedy.
4. Select **And** as the logical connector.
5. Construct query sentence 2 with year is equal to 1980.
6. Click on **Apply Now.**

Other times you may want to set up a logical **OR** condition. That is the selected records need only meet one OR the other criteria. This is achieved in the same way as above with the exception that the **Or** connector is used. This approach is more menu orientated than Microsoft Works 2 and students do not have to be as exact with syntax.

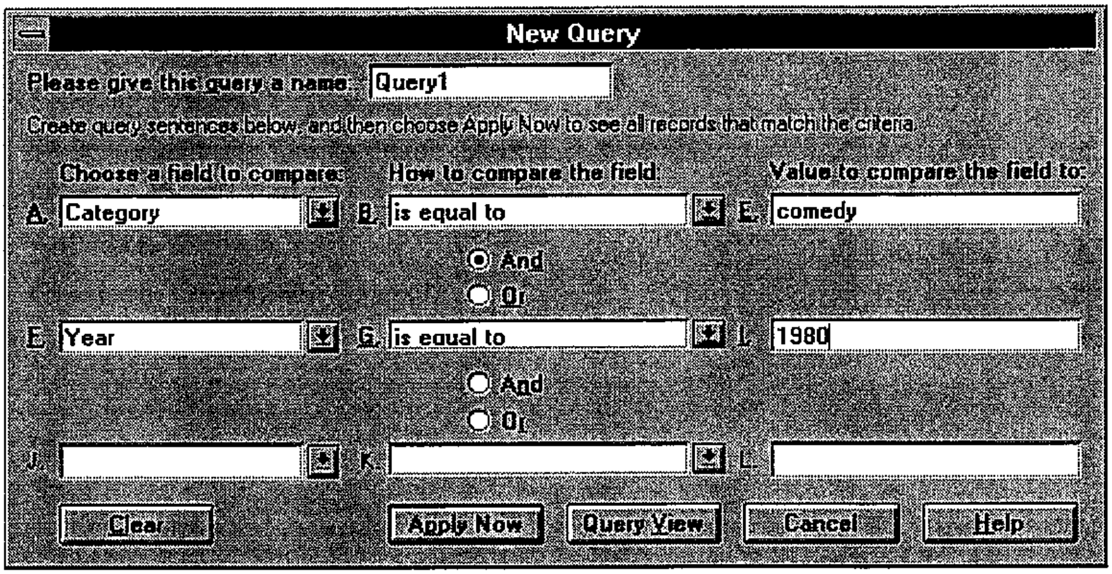

Figure A1.7 Microsoft Works 3 Query

Appendix 2

Instrumentation

Questionnaires, Tests, and Surveys

Testing Instruments

During the main study the various questionnaires, tests, and surveys represented in the table of contents were grouped to form the testing instruments. Table A2.1 shows the composition of the testing instruments. Some testing instruments contain the same items, as these instruments were administered as pre-tests at the commencement of the study and post-tests near the conclusion to the study.

Table A2.1 The Main Study Testing Instruments

No.	Questionnaires, Tests, & Surveys	Origin	No. Items	No. Scales
1	Name School Age Gender Computer Experience Information Processing 1	 Beamish 1994 Beamish 1994 Beamish 1994 Beamish 1994 Beamish 1994	1 1 1 1 18 13	- - - - 1 2
2	Information Processing 2 Personality	Beamish 1994 Beamish 1988	19 12	3 1
3	Content Knowledge	Beamish 1994	32	3
4	Learning Process Questionnaire Stident Flexibility Questionnaire (secondary)	Biggs 1987 Cantwell & Beamish 1994	36 21	6 3
5	Knowledge	Beamish 1994	32	3
6	Database Processing	Beamish 1994	21	1
7	Information Processing 2	Beamish 1994	19	3
8	Information Processing 1 Attitude to Computers	Beamish 1994 Beamish 1988	13 14	2 1
	Classroom Observation Schedule	Beamish 1994		

Learning with Computers

We are doing research into how students learn when using computers.

We are asking you to complete this questionnaire and we wish you to know that anything you tell us will not be passed on to anyone else. It will be confidential. Results will be reported in general terms and neither you nor your school will ever be identified.

Please place a tick, write an answer, or circle the numbers to the right as is appropriate.

1. Your Age Please write your age in years and months.

.... years .... months.

2. Your Sex

Male ------------------ 1

Female ------------------ 2

3. Do you have a computer at home ?

Yes ---------------------- 1

No ---------------------- 2

4. If you answered Yes to Question 3, what type of computer do you have at home? Please tick a box.

Commodore	[ ]	Apple	[ ]
Amiga	[ ]	Macintosh	[ ]
IBM	[ ]	Tandy	[ ]
Atari	[ ]	Sega	[ ]
Other	[ ]	Please specify:....................	

5. How much do you use your home computer?

Never -- 1

Rarely (less than once a month) ------------- 2

Occasionally (about once a month) ---------- 3

Frequently (about once a week) ------------- 4

Very Frequently (more than once a week) -- 5

6. What is your main use of computers at home?

Word Processing	[ ]	Graphics	[ ]
Games	[ ]	Programming	[ ]
Other	[ ]	Please give details:.................	

....

....

7. How often do you use the computers at school in classtime?

Never -- 1

Rarely (less than once a month) ------------ 2

Occasionally (about once a month) ---------- 3

Frequently (about once a week) ------------ 4

Very Frequently (more than once a week) -- 5

8. What is your main use of computers at school during classtime?

Word Processing	[ ]	Graphics	[ ]
Games	[ ]	Programming	[ ]
Other	[ ]	Please give details:.................	

....

....

9. Do you ever use a computer in classtime outside of your Computing Studies classes?

Never -- 1

Rarely (less than once a month) ------------ 2

Occasionally (about once a month) ---------- 3

Frequently (about once a week) ------------ 4

Very Frequently (more than once a week) -- 5

10. How often do you use the computers at school outside of classtime?

Never -- 1

Rarely (less than once a month) ------------ 2

Occasionally (about once a month) --------- 3

Frequently (about once a week) ------------ 4

Very Frequently (more than once a week) -- 5

11. What is your main use of computers at school outside of classtime?

Word Processing	[ ]	Graphics	[ ]
Games	[ ]	Programming	[ ]
Other	[ ]	Please give details:.................	

....

....

12. Have you used any other computers? (Not at home or school)

Never -- 1

Rarely (less than once a month) ------------ 2

Occasionally (about once a month) --------- 3

Frequently (about once a week) ------------ 4

Very Frequently (more than once a week) -- 5

13. What is your main use of other computers? (Not at home or school)

Word Processing	[ ]	Graphics	[ ]
Games	[ ]	Programming	[ ]
Other	[ ]	Please give details:.................	

....

....

14. Have you ever used a database program on a computer?

Never --- 1

Rarely (less than once a month) ------------ 2

Occasionally (about once a month) ---------- 3

Frequently (about once a week) ------------- 4

Very Frequently (more than once a week) -- 5

15. Have you been taught how to use a database at school before?

Yes --------------------- 1

No --------------------- 2

16. If you answered yes to Question 15, please indicate in which years you have been taught to use databases. Tick more than one if necessary.

Primary School	[ ]	Year 8	[ ]
Year 7	[ ]	Year 9	[ ]

17. Do you know how to use a database program to look through information and can you do this without any help?

Yes --------------------- 1

No --------------------- 2

18. Do you know how to use a database program to sort information and can you do this without any help?

Yes --------------------- 1

No --------------------- 2

19. If you were given a database that contained information on cities in Europe, would you know how to use this database to answer questions on these cities without any help?

Yes --------------------- 1

No --------------------- 2

20. Have you ever solved problems that required you to use a database program to find the answer?

Yes --------------------- 1

No --------------------- 2

Information Processing

Quiz 1

We are interested in how students solve problems that use information. Thank you for helping us by doing this quiz.

Please write your name, class and school on the front of the answer booklet.

Please answer the following questions about solving problems. Think carefully about each question and then write the correct answer in the space provided on the answer sheet.

Answer all the questions.

Example. **How many points are awarded for a try in rugby league?**

A. None
B. Two
C. Three
D. Four

Do not continue past this point until instructed to by the teacher

1. John was going to the Newcastle Show. His mother gave him ten dollars to spend on show bags. In the newspaper the day before the show started, there was a list of all the show bags that were for sale as well as their price and the number of items they contained. John went through the list and noticed that:

As the price of the showbags went up, the number of items they contained did not also go up.

The best conclusion he could draw from this is that:

A. Showbags are good value for money.

B. If a showbag had fewer items, it still may be worth buying as each of the items may be more valuable.

C. The show is expensive to get in to.

D. The most expensive showbags have nothing in them.

2. A book on Movies contained information under the following headings:

Name of the Movie
Type of Movie (Western, Horror, Comedy etc...)
Movie Director
Year the movie was made
Cost of the movie to make
Rating of the movie by a film critic

Which one of the following conclusions could best be studied using this information only?

A. Silvester Stallone starred in many films and all were very popular.

B. From 1935 movies were all in colour.

C. Star Wars took three years to make.

D. Oliver Stone mainly directed Comedy movies.

3. Information from the book on Movies in question 2 was placed in a database on a computer. It was sorted in an order based on the year that each movie was made. Movies made in the early 1900's came first and those made in 1994 came last.

It was found that as the years progressed, there were films with different ratings in each of the years.

The conclusion that could best be drawn from this is:

A. Modern ways to make movies that use the latest equipment do not always produce movies that are well rated by the critics.

B. Movies that are in colour take longer to make than those that were made in black and white.

C. Many movies earn a lot of money even though they receive a low rating from a film critic.

D. Clint Eastwood usually stars in Western movies.

4. The information on how much money each movie made was added to the database on Movies in question 3. It was then sorted according to how much money movies made. It was then found that:

All of the movies that had made more than 50 million dollars were made in colour.

The conclusion that could best be drawn from this is:

A. If a movie is made in colour it will earn a lot of money.

B. Older movies were not as good as modern movies.

C. Modern movies earn more money than older movies because people have to pay much more to see them.

D. Good actors like movies to be made in colour.

5. A business man wished to make a movie. He used the movie database to help him decide which type of movie he would make. He sorted the movies so that those that had made the most money were at the top of his list. He then looked at the cost of making the movies and found that:

As earnings went up, the cost of making a movie did not necessarily also go up.

The best conclusion he could draw from this is that:

A. The more a movie costs to make the more it will earn.

B. For a movie to make money it must have good actors in it.

C. Films in English generally earn more money as more people can see them.

D. The amount of money a movie will earn is hard to predict as it depends upon a lot of factors and not just the cost of making it.

6. A database on Dinosaurs is to be constructed using the following categories:

Name
Time period on Earth when they were alive
Weight
Height
Length
Description of Dinosaur
Diet

Which conclusion could best be studied using the information contained in this database?

A. Most meat eating dinosaurs used to hunt their prey in groups in a similar way that lions do today.

B. Nearly all dinosaurs that walked on their back legs were only found where America is today.

C. Most of the largest dinosaurs were plant eaters.

D. Most plant eating dinosaurs lived in swamps.

7. In a study of dinosaurs for the movie Jurassic Park, film makers sorted the Dinosaur database into meat eaters and plant eaters. They found that generally plant eaters weighed more than meat eaters.

The conclusion that can best be drawn from this is:

A. What dinosaurs eat and what they weigh is not related.

B. Meat eaters generally weighed less so that they could move faster to catch their prey.

C. There are more plant eaters than meat eaters.

D. Plant eaters generally lived longer than meat eaters.

8. The editor of a newspaper was looking to employ a new person as a sport reporter. He placed an add in the paper and asked those people interested to supply information on the following:

Name
Age
School results
Experience as a reporter
Examples of written work
Sporting experience as a player
Favourite sports to watch
Reasons for wanting to become a sports reporter.

From this information which of the following could he <u>NOT</u> conclude:

A. Tall people have had more experience playing sport.

B. Those people who had good school results sent in the best examples of written work.

C. People like to watch sports that they enjoyed as a player.

D. People have different reasons for wanting to become a sporting journalist.

9. John was planning a world trip. The air ticket he purchased allowed him to stop off in two different countries as he flew from Sydney to London, and to stop twice on the way home. To help him decide at which countries he wished to stop, he wrote to various travel agents and asked them to provide him with information about countries he had to choose from.

He received back information on various country's climates, tourist attractions, local customs, food, and travel restrictions.

From this information he could best conclude:

A. Countries that were fairly poor had many different religions.

B. The climate of a country and the main foods of the country are closely related.

C. He would arrive in London feeling very tired.

D. It is cheaper to travel in countries that have warm climates.

10. In a study on unemployment in Australia, the states were put in order of increasing unemployment and it was found that:

As the number of unemployed people in each state increased, the amount of money that was spent on education in the state dropped.

The conclusion he could best draw from this is:

A. Unemployment and education are not related.

B. States with warmer climates spent more on education.

C. When governments spend more on education, people can become better trained, and it is easier to get a job.

D. The more governments spend on education, the harder it is for people to find work.

11. A database was established that contained information about various countries of the world. The countries were sorted in order of how much money they made. It was then found that:

As the amount of money a country made increased, the number of people that work as farmers decreased.

The best conclusion he can draw from this is:

A. Countries that have a lot of people working as farmers can produce a lot of food and their people rarely go hungry.

B. Those countries that can earn a lot of money also pay their farmers a lot of money.

C. The number of farmers that a country has, and the amount of money it makes, are not related.

D. Farming does not earn a lot of money for a country.

12. A man was looking to buy a present for his wife. He knew she enjoyed painting and wanted a new set of paints. He looked up the yellow pages and contacted some shops. Upon asking prices he found that:

Shops near the centre of the city were cheapest while those out from the city were more expensive.

The best conclusion he could draw from this is that:

A. Shops near the centre of the city can sell their goods at lower prices than shops out of the city.

B. There was no relationship between distance from the city and price.

C. Shops out from the city centre had a lot of customers.

D. Shops near the centre of the city had better quality goods than shops out from the centre of the city.

13. Students in year 9 were studying how long people live in various countries around the world. They collected information on different countries under the following headings:

Region of the world (Europe, Africa, America, Pacific, etc..)
Country Name
Type of Climate
Average life span of people in the country
Average amount of food eaten by a person in a day

Which one of the following conclusions could best be studied using this information only?

A. The number of people that live in any one country depends upon the region of the world the country is found in.

B. The number of doctors in each country will have an affect on the life span of people in that country.

C. Countries where people have more food to eat also send a lot of food overseas to other countries.

D. The life span of people in a country is influenced by the amount of food they eat.

14. A man wished to buy a car. He purchased a copy of the Trading Post Newspaper and looked through the car ads. Each ad. contained the following information:

Make and Model of Car
Year of manufacture
Car's general condition
Extras fitted to car (eg. towbar, sunroof etc...)
Purchase price

From this information alone he could best conclude:

A. It is better to buy a car from out of the newspaper than from a car dealer.

B. It would work out cheaper for him to catch a bus every day than buy a car.

C. As the years pass, some models of cars seem to hold their value more than others.

D. Banks offer very good loans to people who wish to buy a car.

15. John was in year 9 and had to complete a project for Geography on the States of Australia. To do this he constructed a database in which he collected information for each state under the following headings:

Name of state
The number of people in each state
The number of people that live in cities
The number of people that live in the country
The number of unemployed people
The number of people in prison
Average income per person

From this information alone he could best conclude:

A. States with more people have a problem with rubbish disposal.

B. The more people unemployed in each state, the more people there are in prisons.

C. The average income per person is directly related to the kinds of industry that there is in the state.

D. More petrol is consumed in the city than in the country.

16. On the first day of the new year the local radio station plays and counts down the Newcastle's top 100 songs of the previous year. The list of these songs appears in the Newspaper on the same day so that people can follow it and listen. The list contains information on:
the name of the song
the person or band who sang and played the song
the person who wrote the song
how high it reached in the top 40
how many copies of the record were sold.

From this information alone you could best conclude:

A. Australian music is very popular overseas.

B. People's taste in music is likely to change over the years.

C. Music in the top 40 is liked mainly by young people.

D. Some singers often get high up in the top 40 but they do not write any of their own music.

Information Processing

Quiz 2

We are interested in how students solve problems that use information. Thank you for helping us by doing this quiz.

Please write your name, class and school on the front of the answer booklet.

Please answer the following questions about solving problems. Think carefully about each question and then write the correct answer in the space provided on the answer sheet.

Answer all the questions.

Example. **How many legs has a spider got?**

A. **Two**
B. **Four**
C. **Five**
D. **Eight**

Do not continue past this point until instructed to by the teacher

1. Below you will find the names of 4 topics, each given a number. In what order should they be placed if you wanted to start with the biggest, broadest and most general topic and end with the smallest, narrowest and most specific topic?

1 Batsmen
2 Sport
3 Team Sports
4 Cricket

A. 2, 1, 4, 3
B. 4, 2, 3, 1
C. 2, 3, 4, 1
D. 2, 4, 1, 3

2. A new newspaper in town is trying to organise the list of people who buy the newspaper to help get the papers delivered easily and quickly. If you wanted the list to be **MOST USEFUL** to delivery people, what would be the best way to organise the list?

A. By surname
B. By street name and house number
C. By postcode
D. By firstname

3. The president of the national Michael Jackson fan club has the names and addresses of all club members across Australia. When she sends everyone a membership list, she wants members to be able to find out where other members live in their local area. What would be the **BEST** way for her to organise the list?

A. By surname
B. By city or town
C. By state
D. By postcode

4. A database (a collection of information on cards or maybe on a computer) was set up to provide information about various countries around the world. The information was grouped under the following headings:

Region of the World (Europe, Africa, America etc...)
Country name
Average number of years people live
Amount of people for every Doctor
Average amount of food consumed by a person in a day
Number of children going to primary school
Number of children going to high school
Population
Population growth
GNP (the amount of money that a country earns)
Number of people that work as farmers
Exports (Goods that the country sells overseas to make money)
Public Debt (the amount the country owes other countries)

You are trying to determine whether the amount of education that people get in a country has an effect on the amount the country will earn.

Which one of the following choices would provide you with enough data to be able to make a decision by considering the smallest number of fields?

A. Country, Number of children going to primary school.

B. Country, Number of children going to primary school, Number of children going to high school, GNP.

C. Country, Number of children going to primary school, Number of children going to high school, GNP, Public Debt .

D. Country, Number of children going to primary school, Number of children going to high school, GNP, Public Debt, Exports, Population.

5. Every morning a postman has to sort the mail that he is to deliver that day. On the front of each envelope there is the following information:

Name
Street No.
Street Name
Suburb
Postcode

And on the back of the envelope is the Sender's Information.

He wishes to sort the mail in a way that will take the least amount of time and also enable him to deliver it in the shortest possible time.

In which order should he sort the mail? By:

A. Postcode then Suburb then Street Name then Street No.

B. Surname then Street No then Street Name then Postcode.

C. Sender's Information then Postcode then Street Name then Surname.

D. Street Name then Street No then Surname then Postcode.

6. Let's suppose you were about to look for information about NASA's Space shuttle program. If you were to look up some information in an Encyclopedia which of the following categories of information would give you the **LEAST USEFUL** information?

A. Us. Space Program
B. Nasa
C. Astronauts
D. The Moon

7. You are a filing clerk for a company. You are in charge of 5 file cabinets, each containing different information, as follows:

Cabinet #1	Contains records on all the people employed by the company.
Cabinet #2	Contains records on what is currently in the warehouses.
Cabinet #3	Contains records on the company's sales.
Cabinet #4	Contains information about customers.
Cabinet #5	Contains information about products.

Your company is planning what products to make next year, and how many of each to make. Which cabinets would be MOST HELPFUL in assisting the company in this planning?

A. #1 only
B. #1 and #2
C. #3 and #4
D. #5 only

8. You are working with a database (a collection of information, on cards or maybe on a computer) that contains information about countries in Asia. Each card has facts on the following topics:

1 Name Of Country
2 Climate
3 Major Religions
4 Government
5 Population
6 Typical Clothing
7 Main Foods
8 The Economy
9 Number Of People Unemployed
10 Average Annual Income Per Person
11 No.of Children Per Family
12 Amount Of Farming

You are given the following question:

In Australia the type of clothes that people wear has got more to do with the climate than the work that they do.

Does this seem to be true for the countries in Asia?

Of the 10 topics in the database, which TWO topics would be MOST USEFUL to you in answering the question?

A. #2 and #6
B. #7 and #12
C. #6 and #10
D. #2 and #11

9. Referring to the same question and database as in Question 8:

Which TWO topics would be LEAST USEFUL to you in answering the question?

A. #6 and #12
B. #8 and #2
C. #4 and #11
D. #2 and #6

10. You are working with the same database as in Question 8.

You are given the following question to answer:

Those countries that rely heavily on farming are more likely to suffer from overpopulation. Is this view supported by the data?

Of the 13 topics in this imaginary database, which TWO topics would be MOST USEFUL to you in answering the question?

A. #8 and #10
B. #8 and #2
C. #5 and #12
D. #8 and #11

11. For this question, we'll refer to the same database as in Question 8. Which of the following actions would help you answer the question (the same question as in **10**) ie.

Those countries that rely heavily on farming are more likely to suffer from overpopulation. Is this view supported by the data?

MOST quickly and easily?

A. Sort the cards by NAME OF COUNTRY.

B. Sort the cards by NUMBER OF PEOPLE UNEMPLOYED.

C. Sort the cards by AVERAGE ANNUAL INCOME PER PERSON.

D. Sort the cards by NUMBER OF FARMERS.

12. You are working with a database about Australian States, on cards or on a computer. For each state, the following data are recorded:

1 Name Of State
2 Population
3 Area
4 Average Annual Income Per Person
5 Number Of People Unemployed
6 Number Of People Receiving Welfare
7 Average Years A Person Spends In School
8 Number Of Farmers
9 Number Of People Working In Heavy Industry
10 Amount Of Money Spent On Education
11 Number Of People In Prison
12 Average Age Of Residents
13 Average Annual Temperature

You are given the following statement to test:

A larger number of retired people live in states with warm climates than in states with cold climates.

As a starting point in testing this statement, which of the following ways of sorting the data would BEST help you get information you need?

A. Take notice of NAME OF STATE, AVERAGE ANNUAL TEMPERATURE, and AVERAGE AGE OF RESIDENTS and then Sort by NAME OF STATE.

B Sort by NUMBER OF FARMERS, and then take notice of NAME OF STATE, AVERAGE ANNUAL TEMPERATURE, and AVERAGE AGE OF RESIDENTS.

C Sort by AVERAGE ANNUAL TEMPERATURE, and then take notice of NAME OF STATE, AVERAGE ANNUAL TEMPERATURE, and AVERAGE AGE OF RESIDENTS.

D Sort by NUMBER OF UNEMPLOYED, and write down NAME OF STATE, AVERAGE YEARS A PERSON SPENDS IN SCHOOL, and AVERAGE AGE OF RESIDENTS.

13. For this question, we'll refer to the same database as in Question 12 on the previous page. Sometimes putting data in a special order can help answer a question more quickly or easily. Imagine that a computer can sort the cards in the Australian States database automatically. You can sort the cards based on any of the 13 topics on each card.

You are given the following claim to test:

When state governments do not spend money on education, their states will become poor.

Which of the following actions would help you test this claim MOST quickly and easily?

A. Sort the cards by AVERAGE ANNUAL INCOME PER PERSON, and write down the AMOUNT OF MONEY SPENT ON EDUCATION.

B. Sort the cards by NUMBER OF PEOPLE UNEMPLOYED, and write down the AMOUNT OF MONEY SPENT ON EDUCATION.

C. Sort the cards by NUMBER OF PEOPLE WORKING IN HEAVY INDUSTRY, and write down the AMOUNT OF MONEY SPENT ON EDUCATION.

D. Sort the cards by NUMBER OF PEOPLE IN PRISON and write down the NUMBER OF PEOPLE UNEMPLOYED.

14. You are working with the database about Australian States in question 12.

You are given the following statement to test:

States that have a large area of land also have a lot of people working as farmers.

Which one of the following choices would provide you with enough information to be able to make a decision using the SMALLEST NUMBER of fields?

A. NAME OF STATE, POPULATION

B. NAME OF STATE, POPULATION, AREA

C. NAME OF STATE, POPULATION, AREA, NUMBER OF FARMERS

D. NAME OF STATE, POPULATION, AREA, NUMBER OF FARMERS, NUMBER OF PEOPLE WORKING IN HEAVY INDUSTRY

15. I have a problem for you that may sound familiar; you have to solve problems like this one all the time.

Here's the problem:

Your family has just driven into an unfamiliar town after a long drive, and you're dying to find a Pizza Hut! You stop at a petrol station to ask for directions. Here's what the petrol station attendant says:

You're in luck! There's a Pizza Hut right in town, and it's easy to get to. All the streets to the restaurants have lots of traffic lights to use as guides. First, follow the road that runs in front of the petrol station - that's Main street. Go through 4 traffic lights, then Main Street stops at a "T". Turn left onto Oak road. Go through 3 traffic lights. At the 4th set of traffic lights, take a right onto an unmarked street called Belvedere Drive. Take your first right. There are shops on both sides of the road. Pizza Hut will be on the left. You can't miss it!

Here's what YOU have to answer:

What information in these directions is NOT needed in order for you to find your way to Pizza Hut?

A. The number of traffic lights on Main street
B. The number of traffic lights on Oak Road
C. Which way to go on Belvedere Drive
D. Where to look for the Pizza Hut

16. Referring to the Pizza Hut problem above,

What information, if any, is MISSING from the directions that are needed in order to find the restaurant?

A. Which way to go on Oak Road
B. The direction to travel on Main Street
C. How far to drive on Belvedere Drive
D. There is no information missing in order to find the restaurant

17. Referring to Question 15 above, suppose your family finished lunch at Pizza Hut and discovered that you'd left the road map back at the petrol station.

Assuming you remember the directions that brought you to the restaurant, what other directions would you need to ask for, if any, in order to get back to the gas station?

A. Which way to turn out of the Pizza Hut parking lot
B. How far to drive to get to Belvedere Drive
C. Which way to drive on Oak road
D. You can get there without asking for any additional information

18. Here's a puzzler for you:

On Jason Street, there are three houses in a row, and in front of each house is a car. The colours of the houses are blue, yellow and green (not necessarily in that order). The colours of the cars are red, orange, and white (also not necessarily in that order):

THE GOAL is to put the houses and cars in the right order, by colour.

Here are the 3 facts:

The red car is parked in front of the yellow house.
Viewed from the street, the yellow house is to the left of (but not necessarily next to) the green house.
The blue house has a white car parked in front of it.

YOUR JOB is to tell me which ONE of the following pieces of information you need to put the houses and cars in a single order. (Feel free to draw on the answer sheet if you want to.)

A. The yellow house is next to the blue house
B. The green house is next to the blue house
C. The orange car is NOT parked next to the red car
D. The white car is NOT parked in front of the yellow house

19. A Movie database was constructed with the following fields:

Name of the Movie
Type of Movie (Western, Comedy, Horror etc...)
Rating of the movie by a film critic
Movie Director
Cast (Actors in the movie)
Censorship rating (G, PG, M, R)
Year the movie was made.
Colour or Black and White
Length
Cost of making the movie
The amount of money the movie made
The main story in the Movie

You wish to determine which of the movies are the most popular with the viewing public.

Which one of the following choices would provide you with enough information to be able to make a decision using the <u>SMALLEST NUMBER</u> of fields?

A. Name, Rating by a film critic, Year.

B. Name, Rating by a film critic, The amount of money the movie made, Year.

C. Name, Rating by a film critic, The amount of money the movie made, Year, Director, Cost.

D. Name, Rating by a film critic, The amount of money the movie made, Year, Director, Cost, Cast, Censor, Plot.

20. Below are the fields from the movie database in question 19:

Name of the movie
Type of movie (Western, Comedy, Horror etc...)
Rating of the movie by a film critic
Movie Director
Cast (Actors in the movie)
Censorship rating (G, PG, M, R)
Year the movie was made.
Colour or Black and White
Length
Cost of making the movie
The amount of money the movie made
The main story in the Movie

You wish to determine:

Around what years did movies make the move from black and white to colour.

Of the 12 topics in the database, which TWO would be <u>MOST USEFUL</u> to you in answering the question?

A. Year, Colour.

B. Name, Plot.

C. Colour, Name.

D. Year, Cost.

21. From the movie database above, you wish to determine:

What were the most popular type of movies in the 1980's.

Which one of the following choices would provide you with enough information to be able to make a decision using the <u>SMALLEST NUMBER</u> of fields?

A. Name, Year the movie was made.

B. Name, Year the movie was made, Colour or Black and White.

C. Name, Year the movie was made, Colour or Black and White, Type of Movie.

D. Name, Year the movie was made, Colour or Black and White, Type of Movie, Cost.

About You

Please respond to each of the following questions by circling either YES or NO. Answer all questions.

1.	Are you usually carefree?	Yes No
2.	Do you generally do and say things quickly without stopping to think?	Yes No
3.	Would you do almost anything for a dare?	Yes No
4.	Do you often do things on the spur of the moment?	Yes No
5.	Do you like going out a lot?	Yes No
6.	When people shout at you do you shout back?	Yes No
7.	Can you usually let yourself go and enjoy yourself a lot at a good party?	Yes No
8.	Do other people think of you as being lively?	Yes No
9.	Do you like doing things in which you have to act quickly?	Yes No
10.	Do you like talking to people so much that you never miss a chance to talk to a stranger?	Yes No
11.	Would you say that you are fairly self-confident?	Yes No
12.	Can you easily get some life into a rather dull party?	Yes No
13.	Do you like playing pranks on others?	Yes No

High School Quiz

Answer the following questions by writing the letter that matches the correct answer on the answer sheet provided.

1. Police were investigating a break in at the local shopping centre. They went to the local school with their police records and compared them to the students at the school who had been suspended. Which of the following do you think they found?

A. None of the students who had been in contact with the police had been suspended and there was no relationship between student's contact with the police and school suspensions.

B. Those students who had been in contact with the police had also been suspended.

C. Only some of those students who had been in contact with the police had been suspended but there was a definite relationship.

D. A couple of the students who had been in contact with the police had been suspended but there was no relationship between the two.

2. Police looked over their records on students who had been in contact with them and took particular notice of the sex of the student. Which of the following do you think they found?

A. There is no connection between the sex of the student and the number of police contacts they have had.

B. There is a connection between the sex of the student and the number of police contacts with males being more likely to have been in contact with the police.

C. There is a connection between the sex of the student and the number of police contacts with females being more likely to have been in contact with the police.

D. There is a connection between the sex of the student and the number of police contacts with females and males being equally likely to have been in contact with the police.

3. Which age group at school do you think is more likely to have been in contact with the police?

A. 12 - 13 years
B. 14 - 15 years
C. 16 - 17 years
D. 18 - 19 years

4. In which family income range are most students who come into contact with the police:

A. $15000 - $24000
B. $25000 - $34000
C. $35000 - $44000
D. $45000 - $54000

5. Which of the following will have the greatest influence on whether a person will come into contact with the police?

   A. Number of children in the family.
   B. Whether the parents are divorced.
   C. Student name.
   D. Student's sporting ability.

6. Which of the following statements best describe high school students' interaction with police.

   A. Students who come into contact with the police do so for a variety of reasons and it is impossible to identify them.

   B. High school students do not come into contact with the police.

   C. High school students who come into contact with the police quite often have a common background and it is possible to identify them.

   D. High school students who come into contact with the police quite often have a common background and it is not possible to identify them.

7. A high school principal was looking at the detention record book that showed school suspensions. In this book he most likely would have noticed:

   A. Both males and females have received an equal number of suspensions.

   B. Males have been suspended from school more than females.

   C. Females have been suspended from school more than males.

   D. Suspensions were so rare it was hard for him to make a decision.

8. Which age group do you think is more likely to have been suspended from school?

   A. 12 - 13 years
   B. 14 - 15 years
   C. 16 - 17 years
   D. 18 - 19 years

9. Which of the following do you think the principal could have concluded?

   A. All students have an equal chance of being suspended.

   B. Those students who have come into contact with the police have also usually been suspended from school.

   C. There is no relationship between police contacts and student suspensions.

   D. There are more students at the school who have been suspended than have not been suspended.

World Quiz

Answer the following questions by writing the letter that matches the correct answer on the answer sheet provided.

1. A Doctor was doing a study on how long people live. After studying many countries, which of the following do you think he could have concluded?

A. People in countries that are in the same region of the world all tend to live about the same length of time.

B. Every country, even those in the same region of the world, will have very different life expectancies.

C. Life expectancy is not something that you can measure.

D. Countries throughout the world all have roughly the same life expectancy.

2. The doctor collected information under the following two categories for countries around the world:

1. The number of people per doctor
2. The daily number of kilojoules in the diet

After studying the information what do you think he could conclude?

A. The amount of food you eat is more important than access to a doctor if you wish to live longer.

B. The amount of food you eat is not important in deciding how long you will live.

C. Access to a doctor is more important than the amount of food you will eat if you wish to live longer.

D. Access to a doctor is not very important in deciding how long you will live.

3. There are many factors that may affect how long people live. Which of the following factors do you think is the most important?

A. The amount of education a person receives.

B. The number of tourist attractions in a country.

C. The percentage of the population that lives in cities.

D. The country's name.

4. Which of the following will most affect the amount of money that a country will make ?

A. The percentage of the workforce who are farmers.
B. The number of doctors the country has.
C. The rate at which the country's population is growing.
D. The country's climate.

5. What is the relationship between energy a country uses (coal, gas, petrol etc...) and how much money a country has?

A. The more energy a country uses the poorer it is.
B. The more energy a country uses the richer it is.
C. Energy usage and a country's wealth are not related.
D. Energy use and the wealth of the country are only related in cold climates.

6. If you were to give advice to a Prime Minister of a country on how the country could make more money, which one of the following would you choose?

A. Get more of the population to complete at least secondary education.
B. Get more of the population to go to church.
C. Bring more goods into the country.
D. Get as many people as possible working in agriculture.

7. In Australia how long can an average person expect to live?

A. 55 years
B. 67 years
C. 78 years
D. 83 years

8. In which of the following four countries do people live the smallest number of years?

A. Egypt
B. Australia
C. Japan
D. India

9. In which region of the world do people live the longest?

A. Asia
B. Europe
C. Africa
D. Middle East

10. In which region of the world do people live the smallest number of years?

A. Asia
B. Europe
C. South America
D. Africa

11. What country of the world earns the most amount of money?

A. United States of America
B. Switzerland
C. Japan
D. Saudi Arabia

12. Which country's economy is growing the fastest?

A. Hong Kong
B. China
C. United States of America
D. Botswana

13. Which country uses the most amount of energy (coal, petrol, gas, electricity etc...) per person?

A. United States of America
B. Canada
C. Germany
D. Saudi Arabia

14. Which country has the most of its workforce working as farmers?

A. China
B. Mexico
C. Nepal
D. South Africa

Movie Quiz

Answer the following questions by writing the letter that matches the correct answer on the answer sheet provided.

1. Around what years did movies start making the change from black and white to colour?

A. Early 1940's
B. Early 1950's
C. Early 1960's
D. Early 1970's

2. In what movie did Bob Hoskins star in 1988?

A. Star Wars
B. Turner and Hooch
C. Dead Calm
D. Who Framed Roger Rabbit

3. Who were some of the most popular stars of the 1980's?

A. Barbara Streisand, Burt Reynolds
B. Clint Eastwood, Harrison Ford
C. Roger Moore, Paul Newman
D. Rock Hudson, John Wayne

4. In what year did censorship of films under the ratings of G, PG, M, and R commence?

A. 1950
B. 1959
C. 1968
D. 1975

5. What has been the most popular movie of all time up to the release of Jurassic Park in 1993?

A. E.T.
B. Star Wars
C. Superman
D. Rain Man

6. Which of the following is the best way to determine if a movie is successful.

A. By the type of movie it is. (Western, Drama, Comedy, etc...)
B. By the amount of money that the movie has earnt.
C. By the movie's plot (story).
D. By the cast of actors that are in the movie.

7. Which of the following do Movies not do?

A. Entertain
B. Make money
C. Make a point about society
D. Please all people

8. The type of movies that have been more successful than other types over the last decade are:

A. Comedy
B. Westerns
C. Science Fiction Fantasy
D. Drama

9. The best contribution Movies can make to society is:

A. By making movie stars rich and famous.
B. Keeping people entertained and informed.
C. By giving people jobs in the movie industry.
D. By helping us to plan for the future.

Learning Process Questionnaire

This questionnaire contains items about how you go about the various tasks you are given in your studies.

There are no right or wrong responses to the items in this questionnaire. How you respond depends upon your own individual method of learning. No two people would be expected to give the same response to each item.

How to answer:

For each item, there is a row of numbers from 1 to 5 on the answer sheet. Mark your answer by circling **ONE** of the numbers in the row.

The numbers stand for the following responses:

5 ..... This item is *always* or *almost always* true of me

4 ..... This item is *frequently* true of me

3 ..... This item is true of me *about half the time*

2 ..... This item is *sometimes* true of me

1 ..... This item is *never* or *only rarely* true of me

If you think the answer depends upon the subject(s) being learnt, give your answer in response to the subject(s) that is most important to you.

Answer every item, and do not spend too long on each item.

Your answers are CONFIDENTIAL.

Thank you for your co–operation.

Practice Item:

Example 1 I prefer to play sport than watch it on television.

1. I choose my present subjects mainly because of career prospects when I leave school, not because I'm particularly interested in them.

2. I find that at times my school work can give me a feeling of deep personal satisfaction.

3. I try to obtain high marks in all my subjects because of the advantage this gives me in competing with others when I leave school.

4. I tend to study only what's set; I usually don't do anything extra.

5. While I am studying, I often try to think of how useful the material that I am learning would be in real life.

6. I regularly take notes from suggested readings and put them with my class notes on a topic.

7. I am put off by a poor mark on a test and worry about how I will do on the next test.

8. While I realise that others sometimes know better than I do, I feel I have to say what I think is right.

9. I have a strong desire to do best in all of my studies.

10. I find the only way to learn many subjects is to memorise them by heart.

11. In reading new material, I am often reminded of material I already know and see the latter in new light.

12. I try to work solidly throughout the term and revise regularly when exams are close.

13. Whether I like it or not, I can see that studying is for me a good way to get a well-paid or secure job.

14. I find that many subjects can become very interesting once you get into them.

15. I like the results of tests to be put up publicly so I can see by how much I beat some others in the class.

16. I prefer subjects in which I have to learn just facts to ones which require a lot of reading and understanding of material.

17. I find that I have to do enough work on a topic so that I can form my own point of view before I am satisfied.

18. I always try to do all my assignments as soon as they are given to me.

19. Even though I have studied hard for a test, I worry that I may not be able to do well on it.

20. I find that studying some topics can be really exciting.

21. I would rather be highly successful in school even though this might make me unpopular with some of my classmates.

22. In most subjects I try to work so that I do only enough to make sure that I pass, and no more.

23. I try to relate what I have learned in one subject to what I already know in other subjects.

24. Soon after a class or lab, I re-read my notes to make sure that I can read them and understand them.

25. I think that teachers shouldn't expect secondary school students to work on topics that are outside the set course.

26. I feel that I might one day be able to change things in the world that I see now to be wrong.

27. I will work for top marks in a subject whether or not I like the subject.

28. I find it better to learn just the facts and details about a topic rather than try to understand all about it.

29. I find most new topics interesting and often spend extra time trying to find out more about them.

30. When a test is returned, I go over it carefully correcting all errors and trying to find out more about them.

31. I will continue my studies only for as long as necessary to get a job.

32. My main aim in life is to find out what to believe in and then to act accordingly.

33. I see doing well in school as a sort of game, and I play to win.

34. I don't spend time on learning things that I know won't be asked in the exams.

35. I spend a great deal of my free time finding out more about interesting topics which have been discussed in different classes.

36. I usually try to read all the references and things my teacher says we should.

Student Flexibility Questionnaire

This questionnaire contains items about how you go about the various tasks you are given in your studies.

There are no right or wrong responses to the items in this questionnaire. How you respond depends upon your own individual method of learning. No two people would be expected to give the same response to each item.

How to answer:

For each item, there is a row of numbers from 1 to 5 on the answer sheet. Mark your answer by circling **ONE** of the numbers in the row.

The numbers stand for the following responses:

5 ..... This item is *always* or *almost always* true of me

4 ..... This item is *frequently* true of me

3 ..... This item is true of me *about half the time*

2 ..... This item is *sometimes* true of me

1 ..... This item is *never* or *only rarely* true of me

If you think the answer depends upon the subject(s) being learnt, give your answer in response to the subject(s) that is most important to you.

Answer every item, and do not spend too long on each item.

Your answers are CONFIDENTIAL.

Thank you for your co–operation.

Practice Item:

Example 1 I prefer to play sport than watch it on television.

1. I think it is very important to vary the way I work to make sure I meet the requirements of each assignment I am given.

2. Sometimes I find different suggestions for ways of going about an assignment to be more confusing than helpful.

3. I find that I have one good way of doing my school assignments, and this works for me nearly all the time.

4. Before starting work on a problem I like to think of different ways of attacking it.

5. While I usually know how to go about doing an assignment, I often find it hard to figure out where all the information I am using fits into my plan.

6. While I know that different assignments and projects sometimes require different ways of being done, I am usually happier to stick to tried and trusted ways.

7. While I usually like to think about the main points and facts of a topic I am doing an assignment on, I also like to think about different ways of putting this information together before I write up my assignment.

8. I often feel that the hardest part of doing assignments is knowing how to do them rather than knowing what to do.

9. I usually end up using my normal way of working even though the assignment I am working on may require me to use several different ways of working.

10. I enjoy it when the problem or assignment I have been given means I have to find different ways of working.

11. Although I usually understand the information that I should include in an assignment, I often have trouble deciding where and when I should use that information when writing the assignment.

12. Once I have found a good way of doing my schoolwork, I feel it is safest to stay with this method.

13. I often find the most interesting part of an assignment is in working out possible ways of doing the assignment, and this often leads me to change from the way I first thought about doing it.

14. While I usually know what I want to put in my assignments, I often get lost when dealing with all the facts and details, and I don't know how to deal with this.

15. I prefer to follow my usual ways of working, even if this isn't exactly what the assignment requires.

16. I often look forward to coming up with new or different ways of doing the assignments I have been given.

17. Although I usually know the main ideas about a topic, I often get caught out when asked for details, and I'm never sure how to overcome this.

18. I rarely change the way I do my school work, even if this doesn't fit what the topic requires.

19. I believe that every problem I am given has its own way of being done, and I change my way of doing my work to match this.

20. I find I am easily distracted from my line of thought as I am working, and this often makes my work disorganised and patchy.

21. I often find I use the same way of working no matter what the unit of work is that I am studying.

Database Knowledge

PART 1

Please answer the following questions by writing the letter that corresponds to the correct answer in the spaces provided on the answer sheet.

1. A database is a:

A. Collection of information
B. Type of computer
C. Type of book
D. Record of numbers

2. An example of a database is:

A. A Street directory
B. A Bank book
C. A Telephone Book
D. An IBM computer

3. The information on each student in a school database is stored in a:

A. Field
B. Record
C. File
D. Book

4. A school database was made up of all the students' names and addresses. What is the smallest piece of information?

A. Disk
B. File
C. Database
D. Record

5. The sort feature on a database helps you to:

A. Organise information into ascending or descending order
B. Conduct scientific experiments more effectively
C. Delete information that you do not need
D. Decide which fields in the database are the most important

Below is a collection of information from a High School:

High School

First-name	Surname	Year	Sex	Age	Police Contacts	Income	Divorced Parents
Peter	Collins	11	M	16	1	24000	N
Wes	Deeps	11	M	16	1	19000	Y
Darryl	Fogarty	11	M	17	1	16000	Y
Fred	Ford	10	M	16	1	21000	Y
William	Greeves	11	M	20	3	24000	Y
Lisa	Gurtrude	9	F	15	1	19000	Y
Sid	Jackson	7	M	12	3	18000	N
Anthony	Jacobs	11	M	17	3	24000	N
Linda	Johnson	9	F	15	1	23000	N
Cathy	Lindyman	8	F	13	3	21000	Y
Ian	McKenzie	11	M	17	2	19000	Y
John	Morris	12	M	17	2	20000	N
Fred	Sampson	9	M	15	1	18000	N
Robert	Sloan	8	M	14	1	22000	N
Filbin	Sloatino	9	M	15	2	27000	N
Alan	Spencer	8	M	13	2	17000	N
Wayne	Sporten	9	M	15	1	23000	N
Kevin	Watterson	9	M	15	1	21000	Y
John	Wayne	9	M	15	2	21000	Y
Sharon	Wellers	12	F	17	1	20000	Y
Steve	Wendon	8	M	14	1	21000	N
Reg	Wilson	9	M	16	2	27000	N
Slavko	Yakov	9	M	15	4	23000	N
Wilhela	Zagorski	9	M	15	3	24000	N

6. How many have 2 police contacts and come from divorced parents?

A. 1
B. 2
C. 3
D. 4

7. How many are in year 7 or 8?

A. 5
B. 7
C. 15
D. 17

8. How many come from families that have an income less than $20 000.00?

A. 3
B. 5
C. 7
D. 9

9. How many are over 15 or come from divorced families?

A. 5
B. 7
C. 12
D. 15

10. If you sorted First Names into ascending alphabetical order, which name would come first?

A. Alan
B. Collins
C. William
D. Anthony

11. If you sorted income into descending order, which entry would come last?

A. $17 000.00
B. $16 000.00
C. $27 000.00
D. $23 000.00

12. If you sorted ages in ascending order, which age would come first?

A. 20
B. 17
C. 14
D. 12

The following information is taken from a database on Television programs.

TV Program	Channel	Time Shown	Length	Country Made
Paradise Beach	9	5:30 pm	30	Australia
Home Improvement	7	8:00 pm	30	USA
Simspons	10	6:30 pm	30	USA
Late Show	2	10:30 pm	60	Australia
Beverley Hills 90210	10	7:30 pm	60	USA
Mr Bean	2	9:00 pm	30	England
Married With Children	9	9:30 pm	60	USA
Dr Quinn	9	8:30 pm	60	USA
Basketball	10	12:00 pm	90	Australia
Talk to the Animals	7	6:30 am	60	Australia
Play School	2	4:00 pm	30	Australia
Sesame Street	2	2:30 pm	60	USA
Neighbours	10	6:30 pm	30	Australia
Full House	7	7:30 pm	30	USA
Quantum	2	8:00 pm	60	Australia
Hail and Pace	9	9:00 pm	30	England
Altogether Now	3	8:00 pm	30	Australia
Sports Sunday	3	4:00 am	120	Australia

13. If the Name of the TV Programs were sorted in ascending order which program would come last?

A. Beverly Hills 90210
B. Dr. Quinn
C. Sports Sunday
D. Mr. Bean

14. How many of the programs are on Channel 9 or made in Australia?

A. 5
B. 9
C. 11
D. 12

15. How many programs are made in England and are shown on Channel 2?

A. 1
B. 3
C. 5
D. 7

PART 2

Fish Database

When your teacher tells you to go to a computer, open the fish database, and answer the following questions by writing your answers in the spaces provided:

1. How many of the fish in the database live in tropical waters? ____________

2. What kinds of food do fish eat? ____________________________________

3. What do Port Jackson sharks eat? ________________________________

4. What fish are found in the deepest water? __________________________

5. A fisherman told his son that fish that eat algae are not found in deep water but are usually found in water no deeper than 30 metres. Is he correct? ______________________________________

6. How many of the fish eat shell fish as part of their diet? ______________

You and Computers

This questionnaire contains statements about how you interact with computers. There are no right or wrong responses to the items and no two people would be expected to give the exact same answer.

For each item, please circle the one response that best describes your use of computers.

Answer every item. Thank you.

Practice Item

I like rugby league football SA A D SD

Key:

SA - Strongly agree
A - Agree
D - Disagree
SD - Strongly Disagree

1. Once I start working with computers I find it very hard to stop.
2. Having computers in every classroom would be fun for me.
3. I would like to spend more time using the school's computers.
4. I can only work on a computer if I have someone helping me.
5. I get a sinking feeling when I think of trying to use a computer.
6. Computers make my life enjoyable.
7. I like, or would like, learning on a computer.
8. Working with a computer would make me very nervous.
9. Computers do not scare me at all.
10. I can only use computers for very easy tasks.
11. I like to take computer courses.
12. Working with a computer would make me very uncomfortable.

Classroom Observations

School ________________ **Class** ____________ **Teacher** __________________

Date ______________

Teaching Process	**Time in 2 Minute Blocks**	**Importance ***
Concept Formation	□□□□□□□□□□□□□□□□□□□□	1 2 3 4 5
Directing	□□□□□□□□□□□□□□□□□□□□	1 2 3 4 5
Instruction of strategies	□□□□□□□□□□□□□□□□□□□□	1 2 3 4 5
Scaffolding	□□□□□□□□□□□□□□□□□□□□	1 2 3 4 5
Modelling of strategies	□□□□□□□□□□□□□□□□□□□□	1 2 3 4 5
Debriefing	□□□□□□□□□□□□□□□□□□□□	1 2 3 4 5
Students on task	□□□□□□□□□□□□□□□□□□□□	1 2 3 4 5 ⊠

Classroom Activity		**Frequency ****
Worksheets	□□□□□□□□□□□□□□□□□□□□	
Working as a group	□□□□□□□□□□□□□□□□□□□□	1 2 3 4 5
Working using Heuristic	□□□□□□□□□□□□□□□□□□□□	1 2 3 4 5
Teacher Engagement		1 2 3 4 5

*** Key to Importance**

1 Extremely Important
2 Very Important
3 Average Importance
4 Little Importance
5 No Importance

**** Key to Frequency**

1 All the Time
2 Most of the Time
3 Some of the Time
4 Rarely
5 Never

Appendix 3

One-factor Congeneric Models

Appendix 3 provides details of the one-factor congeneric models developed using LISREL8.

Introduction

Appendix 3 provides details of the fitted one-factor congeneric models developed using LISREL8 (Joreskog & Sorbom, 1993). The constructs were computed from the maximally weighted, proportional factor score regression coefficients obtained from the one-factor congeneric models. The meaning and interpretation of the composites is discussed more fully in the main body of the text. The data reduction achieved using this approach resulted in 165 indicator variables being reduced to 18 composite constructs, greatly facilitating the development of parsimonious causal models.

Composite variables produced in this way related to student-level data. Student-level composites included the Student Background Model of Personality, the Student Intermediate Models of Computer Experience, Approaches to Learning (Surface, Deep, Achieving), and Flexibility in Learning (Adaptive, Inflexible, Irresolute), and the Student Outcome Models of Information Processing (Hypothesis Testing, Interpretation of Data, Sufficient Information, Association of Data, Information Processing), Attitude to Computers (Liking, Confidence), Content Knowledge (High School, Movie), and Database Knowledge.

The following tables describe parameter estimates, item reliabilities, factor score regressions, scale reliabilities, and goodness-of-fit measures for each model. Scale reliabilities were assessed using the coefficient of multiple determination ($\rho\xi_x$) obtained from equivalent LISREL7 models (Joreskog & Sorbom, 1989)

Appendix 3.1 Student Background and Intermediate Models

Eight separate student background and intermediate models were developed for use in the study relating to personality, computer experience, approaches to learning, and flexibility in learning. These formed the presage factors in the multilevel model and the individual constructs were computed from the maximally weighted, proportional factor score regression coefficients obtained from one-factor congeneric models. Sixty of the original 87 items were found to be significant indicators of the presage constructs.

Personality

Personality was assessed as a measure of student extroversion/introversion and was based on the Eysenck Personality Inventory (Eysenck, 1964). This inventory was developed using principal component factor analysis of sets of items and the extroversion/introversion subscale was found to have a reliability of 0.84. Beamish (1988) used this extroversion/introversion subscale and employed principal components factor analytic techniques to develop a 12-item single factor scale with a Cronbach alpha reliability of 0.69. In the present analysis, the same 12 items were used to develop a LISREL8 one-factor congeneric model for the measurement of a personality construct. The procedures for the development of multivariate constructs using LISREL one-factor congeneric models have been explained in Chapter 6. Four of the original 12 personality items (see Beamish, 1988) were found to be significant indicators in the Personality model developed.

Table A3.1 Fitted One-factor Congeneric Model for Personality (N=492)

Personality	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 05	0.787	0.381	0.619	0.259
Item 07	0.805	0.353	0.647	0.286
Item 08	0.793	0.372	0.628	0.267
Item 12	0.719	0.483	0.517	0.187
Scale Reliability ($\rho\xi_x$) [b]	0.885			
Goodness-of-fit Measures				
Chi-square (χ^2)	3.153			
Degrees of Freedom (df)	2			
Probability (p)	0.207			
Goodness-of-fit-Index (GFI)	0.997			
Adjusted Goodness-of-fit-Index (AGFI)	0.987			
Root Mean Square Residual (RMR)	0.058			
Root Mean Square Error of Approximation (RMSEA)	0.034			
Normed Fit Index (NFI)	0.984			
Comparative Fit Index (CFI)	0.994			
Incremental Fit Index (IFI)	0.994			
Relative Fit Index (RFI)	0.952			

Notes

a. Proportionally weighted factor score regressions.
b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Computer Experience

Students came to the study with a variety of previous experiences with computers. During the study students were asked about their previous experience with computers at home, at school, and at places other than home and school. They were also asked about their previous experience when working with databases. All types of experience add to develop a confidence and facility of computer use and the responses to these items combine to indicate the previous experiences that students have had using computers. Beamish (1988) used principal component factor analytic techniques to develop a scale for previous computer experience. The current analysis uses LISREL8 to develop a one-factor congeneric model for the measurement of a computer experience construct. The Student Computer Experience Construct was computed from the maximally weighted, proportional factor score regression coefficients obtained from the one-factor congeneric model. Six of the original 18 computer experience items were found to be significant indicators of the computer experience model.

Table A3.2 Fitted One-factor Congeneric Model for Computer Experience (N=541)

Computer Experience	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 01	0.757	0.427	0.573	0.394
Item 02	0.654	0.572	0.428	0.331
Item 03	0.750	0.437	0.563	0.076
Item 04	0.780	0.392	0.608	0.063
Item 05	0.791	0.375	0.625	0.070
Item 07	0.720	0.481	0.519	0.066
Scale Reliability ($\rho\xi_x$) [b]	0.894			
Goodness-of-fit Measures				
Chi-square (χ^2)	9.469			
Degrees of Freedom (df)	7			
Probability (p)	0.221			
Goodness-of-fit-Index (GFI)	0.997			
Adjusted Goodness-of-fit-Index (AGFI)	0.992			
Root Mean Square Residual (RMR)	0.028			
Root Mean Square Error of Approximation (RMSEA)	0.026			
Normed Fit Index (NFI)	0.995			
Comparative Fit Index (CFI)	0.999			
Incremental Fit Index (IFI)	0.999			
Relative Fit Index (RFI)	0.989			

Notes

a. Proportionally weighted factor score regressions.

b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Approaches to Learning

The Learning Process Questionnaire (LPQ) was developed by Biggs (1987) for use with secondary students in assessing their preferred approach to learning. Biggs identified that students prefer to adopt either a deep, surface, or achieving approach to their learning. Each approach is made up of student motive and strategy subscales, and consequently the LPQ contains six scales of six items each. Research results confirm the three factor solution (Watkins & Hattie, 1990; Kember & Gow, 1991; Watkins et al., 1991) with Cronbach alpha for the six subscales ranging from 0.51 (Surface Motive) to 0.77 (Achieving Strategy). Using LISREL generalised least squares Biggs (1994) found that all scales had goodness of fit estimates higher that 0.97, with root mean square residuals higher than the accepted 0.05.

In the current study, LISREL8 was used to develop one-factor congeneric models for the measurement of the Preferred Approach to Learning constructs. These constructs were computed from the maximally weighted, proportional factor score regression coefficients obtained from this one-factor congeneric model. Details of the Approach to Learning fitted one-factor congeneric models are found in Tables A3.3-A3.5. Twenty-eight of the original 36 items (see Biggs, 1987) were found to be significant indicators in the approaches to learning models.

Table A3.3 Fitted One-factor Congeneric Model for Surface Approach (N=440)

Surface Approach	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 01	0.395	0.844	0.156	0.072
Item 07	0.563	0.683	0.317	0.127
Item 10	0.539	0.709	0.291	0.117
Item 13	0.548	0.700	0.300	0.121
Item 16	0.497	0.753	0.247	0.102
Item 19	0.583	0.660	0.340	0.137
Item 25	0.357	0.873	0.127	0.063
Item 28	0.519	0.731	0.269	0.110
Item 31	0.421	0.823	0.177	0.079
Item 34	0.400	0.840	0.160	0.073
Scale Reliability ($\rho\xi_x$) [b]	0.652			
Goodness-of-fit Measures				
Chi-square (χ^2)	30.305			
Degrees of Freedom (df)	29			
Probability (p)	0.399			
Goodness-of-fit-Index (GFI)	0.988			
Adjusted Goodness-of-fit-Index (AGFI)	0.977			
Root Mean Square Residual (RMR)	0.060			
Root Mean Square Error of Approximation (RMSEA)	0.010			
Normed Fit Index (NFI)	0.886			
Comparative Fit Index (CFI)	0.994			
Incremental Fit Index (IFI)	0.994			
Relative Fit Index (RFI)	0.822			

Notes
a. Proportionally weighted factor score regressions.
b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Table A3.4 Fitted One-factor Congeneric Model for Deep Approach (N=441)

Deep Approach	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 02	0.535	0.714	0.286	0.078
Item 05	0.588	0.655	0.345	0.093
Item 11	0.570	0.675	0.325	0.087
Item 14	0.667	0.555	0.445	0.124
Item 17	0.612	0.626	0.374	0.101
Item 20	0.573	0.671	0.329	0.088
Item 23	0.582	0.662	0.338	0.091
Item 26	0.463	0.786	0.214	0.060
Item 29	0.716	0.488	0.512	0.151
Item 35	0.676	0.543	0.457	0.129
Scale Reliability ($\rho\xi_x$) [b]	0.801			
Goodness-of-fit Measures				
Chi-square (χ^2)	35.913			
Degrees of Freedom (df)	30			
Probability (p)	0.211			
Goodness-of-fit-Index (GFI)	0.986			
Adjusted Goodness-of-fit-Index (AGFI)	0.975			
Root Mean Square Residual (RMR)	0.059			
Root Mean Square Error of Approximation (RMSEA)	0.021			
Normed Fit Index (NFI)	0.926			
Comparative Fit Index (CFI)	0.987			
Incremental Fit Index (IFI)	0.987			
Relative Fit Index (RFI)	0.889			

Notes
a. Proportionally weighted factor score regressions.
b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Table A3.5 Fitted One-factor Congeneric Model for Achieving Approach (N=436)

Achieving Approach	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 03	0.698	0.513	0.487	0.152
Item 06	0.491	0.759	0.241	0.072
Item 09	0.735	0.460	0.540	0.179
Item 12	0.760	0.422	0.578	0.202
Item 18	0.568	0.678	0.322	0.094
Item 27	0.644	0.585	0.415	0.123
Item 30	0.561	0.686	0.314	0.092
Item 33	0.540	0.709	0.291	0.085
Scale Reliability ($\rho\xi_x$) [b]	0.852			
Goodness-of-fit Measures				
Chi-square (χ^2)	24.764			
Degrees of Freedom (df)	18			
Probability (p)	0.132			
Goodness-of-fit-Index (GFI)	0.989			
Adjusted Goodness-of-fit-Index (AGFI)	0.978			
Root Mean Square Residual (RMR)	0.043			
Root Mean Square Error of Approximation (RMSEA)	0.029			
Normed Fit Index (NFI)	0.952			
Comparative Fit Index (CFI)	0.986			
Incremental Fit Index (IFI)	0.987			
Relative Fit Index (RFI)	0.926			

Notes
a. Proportionally weighted factor score regressions.
b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Flexibility in Learning

The Student Flexibility Questionnaire (SFQ) is a 21 item instrument that was developed by Cantwell (1990) to determine students' flexibility in their learning. Within the area of executive strategy control he identified two positive attributes (planning and monitoring) and two negative attributes (inflexibility and irresoluteness). Empirical studies conducted at the tertiary level, first with Education students and then with Nursing students, validated the instrument with the planning and monitoring attributes generalising into a single adaptive strategy control dimension, while the flexibility (algorithmic strategy control) and irresolute dimensions remained as separate negatives. All of the three final factors had a reliability greater than 0.8.

During the pilot study principal components factor analysis of the revised SFQ for secondary students gave two factors with an eigenvalue greater than one. The first factor contained seven items with an alpha reliability of 0.82 (N=152) while the second factor contained 13 items and the alpha reliability was found to be 0.79 (N=152). In the current study, LISREL8 was used to develop one-factor congeneric models for the measurement of the Flexibility in Learning constructs. All 21 of the original items were found to be significant indicators of the Flexibility in Learning models developed.

Table A3.6 Fitted One-factor Congeneric Model for Adaptive (N=423)

Adaptive	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 01	0.589	0.653	0.347	0.136
Item 04	0.569	0.677	0.323	0.126
Item 07	0.666	0.556	0.444	0.181
Item 10	0.568	0.677	0.323	0.126
Item 13	0.624	0.611	0.389	0.153
Item 16	0.593	0.648	0.352	0.138
Item 19	0.598	0.643	0.357	0.140
Scale Reliability ($\rho\xi_x$) [b]	0.842			
Goodness-of-fit Measures				
Chi-square (χ^2)	12.142			
Degrees of Freedom (df)	12			
Probability (p)	0.434			
Goodness-of-fit-Index (GFI)	0.993			
Adjusted Goodness-of-fit-Index (AGFI)	0.984			
Root Mean Square Residual (RMR)	0.031			
Root Mean Square Error of Approximation (RMSEA)	0.005			
Normed Fit Index (NFI)	0.959			
Comparative Fit Index (CFI)	0.999			
Incremental Fit Index (IFI)	0.999			
Relative Fit Index (RFI)	0.928			

Notes

a. Proportionally weighted factor score regressions.

b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Table A3.7 Fitted One-factor Congeneric Model for Inflexible (N=434)

Inflexible	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 03	0.572	0.673	0.327	0.097
Item 06	0.710	0.496	0.504	0.163
Item 09	0.690	0.524	0.476	0.149
Item 12	0.593	0.648	0.352	0.104
Item 15	0.696	0.516	0.484	0.153
Item 18	0.721	0.480	0.520	0.171
Item 21	0.709	0.498	0.502	0.162
Scale Reliability ($\rho\xi_x$) [b]	0.839			
Goodness-of-fit Measures				
Chi-square (χ^2)	13.658			
Degrees of Freedom (df)	11			
Probability (p)	0.252			
Goodness-of-fit-Index (GFI)	0.993			
Adjusted Goodness-of-fit-Index (AGFI)	0.982			
Root Mean Square Residual (RMR)	0.039			
Root Mean Square Error of Approximation (RMSEA)	0.024			
Normed Fit Index (NFI)	0.968			
Comparative Fit Index (CFI)	0.994			
Incremental Fit Index (IFI)	0.994			
Relative Fit Index (RFI)	0.940			

Notes
a. Proportionally weighted factor score regressions.
b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Table A3.8 Fitted One-factor Congeneric Model for Irresolute (N=436)

Irresolute	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 02	0.547	0.700	0.300	0.113
Item 05	0.639	0.592	0.408	0.157
Item 08	0.580	0.664	0.336	0.127
Item 11	0.633	0.599	0.401	0.154
Item 14	0.698	0.512	0.488	0.198
Item 17	0.582	0.662	0.338	0.128
Item 20	0.569	0.676	0.324	0.123
Scale Reliability ($\rho\xi_x$) [b]	0.793			
Goodness-of-fit Measures				
Chi-square (χ^2)	14.464			
Degrees of Freedom (df)	14			
Probability (p)	0.416			
Goodness-of-fit-Index (GFI)	0.992			
Adjusted Goodness-of-fit-Index (AGFI)	0.984			
Root Mean Square Residual (RMR)	0.038			
Root Mean Square Error of Approximation (RMSEA)	0.009			
Normed Fit Index (NFI)	0.950			
Comparative Fit Index (CFI)	0.998			
Incremental Fit Index (IFI)	0.998			
Relative Fit Index (RFI)	0.925			

Notes
a. Proportionally weighted factor score regressions.
b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Appendix 3.2 Student Outcome Models

Information Processing

The Information Processing measure was originally developed by White (1985) and contained the scales of Sufficiency of Information, Relevance of Information, and Organisation of Information. The 16 item instrument failed to load on three independent factors, so all the items were used as a single scale. The reliability of this scale was found to be 0.66. This instrument was further developed by adding the two six item scales of hypothesis testing and interpretation of data. With these scales, the final form of the Information Processing Ability instrument contained 28 items and principal component factor analysis in the pilot study gave a single factor with an eigenvalue greater than one. The factor contained 23 items and the alpha reliability for the scale was found to be 0.84 (N=198).

The Hypothesis Testing, Interpretation of Data, Sufficiency of Data, and Association of Data scales used in the Pilot study were further developed using LISREL8 to develop one-factor congeneric models for the measurement of the information processing constructs. Twenty five of the original 28 items were found to be significant indicators of the information processing models.

Table A3.9 Fitted One-factor Congeneric Model for Hypothesis Testing (N=369)

Hypothesis Testing	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 01	0.627	0.607	0.393	0.155
Item 02	0.805	0.352	0.648	0.342
Item 06	0.709	0.498	0.502	0.213
Item 08	0.725	0.474	0.526	0.067
Item 09	0.751	0.435	0.565	0.107
Item 13	0.502	0.699	0.301	0.117
Scale Reliability ($\rho\xi_x$) [b]	0.821			
Goodness-of-fit Measures				
Chi-square (χ^2)	10.433			
Degrees of Freedom (df)	8			
Probability (p)	0.236			
Goodness-of-fit-Index (GFI)	0.992			
Adjusted Goodness-of-fit-Index (AGFI)	0.980			
Root Mean Square Residual (RMR)	0.045			
Root Mean Square Error of Approximation (RMSEA)	0.029			
Normed Fit Index (NFI)	0.962			
Comparative Fit Index (CFI)	0.991			
Incremental Fit Index (IFI)	0.991			
Relative Fit Index (RFI)	0.929			

Notes

a. Proportionally weighted factor score regressions.

b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Table A3.10 Fitted One-factor Congeneric Model for Interpretation of Data (N=370)

Interpretation of Data	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 03	0.544	0.677	0.323	0.105
Item 05	0.728	0.412	0.588	0.233
Item 07	0.759	0.506	0.494	0.174
Item 10	0.662	0.561	0.439	0.148
Item 11	0.542	0.706	0.294	0.096
Item 12	0.820	0.397	0.603	0.245
Scale Reliability ($\rho\xi_x$) [b]	0.917			
Goodness-of-fit Measures				
Chi-square (χ^2)	10.142			
Degrees of Freedom (df)	8			
Probability (p)	0.255			
Goodness-of-fit-Index (GFI)	0.992			
Adjusted Goodness-of-fit-Index (AGFI)	0.980			
Root Mean Square Residual (RMR)	0.049			
Root Mean Square Error of Approximation (RMSEA)	0.027			
Normed Fit Index (NFI)	0.957			
Comparative Fit Index (CFI)	0.990			
Incremental Fit Index (IFI)	0.991			
Relative Fit Index (RFI)	0.920			

Notes
a. Proportionally weighted factor score regressions.
b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Table A3.11 Fitted One-factor Congeneric Model for Sufficient Information (N=412)

Sufficient Information	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 04	0.627	0.606	0.394	0.207
Item 14	0.645	0.584	0.416	0.220
Item 15	0.546	0.702	0.298	0.156
Item 16	0.448	0.799	0.201	0.112
Item 19	0.725	0.474	0.526	0.305
Scale Reliability ($\rho\xi_x$) [b]	0.759			
Goodness-of-fit Measures				
Chi-square (χ^2)	7.484			
Degrees of Freedom (df)	5			
Probability (p)	0.187			
Goodness-of-fit-Index (GFI)	0.994			
Adjusted Goodness-of-fit-Index (AGFI)	0.981			
Root Mean Square Residual (RMR)	0.048			
Root Mean Square Error of Approximation (RMSEA)	0.035			
Normed Fit Index (NFI)	0.945			
Comparative Fit Index (CFI)	0.980			
Incremental Fit Index (IFI)	0.981			
Relative Fit Index (RFI)	0.891			

Notes
a. Proportionally weighted factor score regressions.
b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Table A3.12 Fitted One-factor Congeneric Model for Association of Data (N=412)

Association of Data	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 06	0.671	0.549	0.451	0.140
Item 07	0.636	0.596	0.404	0.123
Item 08	0.561	0.686	0.314	0.094
Item 10	0.644	0.585	0.415	0.127
Item 12	0.746	0.444	0.556	0.193
Item 13	0.782	0.389	0.611	0.231
Item 16	0.554	0.694	0.306	0.092
Scale Reliability ($\rho\xi_x$) [b]	0.916			
Goodness-of-fit Measures				
Chi-square (χ^2)	15.185			
Degrees of Freedom (df)	11			
Probability (p)	0.174			
Goodness-of-fit-Index (GFI)	0.991			
Adjusted Goodness-of-fit-Index (AGFI)	0.978			
Root Mean Square Residual (RMR)	0.058			
Root Mean Square Error of Approximation (RMSEA)	0.030			
Normed Fit Index (NFI)	0.953			
Comparative Fit Index (CFI)	0.986			
Incremental Fit Index (IFI)	0.987			
Relative Fit Index (RFI)	0.911			

Notes

a. Proportionally weighted factor score regressions.

b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Information Processing

Second Order Factor Analysis

In an attempt to achieve greater parsimony and avoid colinearity problems due to the significant correlations between the information processing constructs, a second order confirmatory factor analysis was performed to see if the first order constructs could form a second order construct. LISREL8 was used to develop a one-factor congeneric model for the measurement of this second order construct. It was not possible to develop a single information processing construct directly from the items used in the various information processing scales due to the size of the sample in the main study. Five items were found to be significant indicators of the second order information processing model.

Table A3.17 Fitted One-factor Congeneric Model for Information Processing (N=292)

Information Processing	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Scale 01 Hypothesis Testing	0.625	0.610	0.390	0.433
Scale 02 Interpretation of Data	0.543	0.706	0.294	0.160
Scale 03 Association of Data	0.596	0.702	0.298	0.209
Scale 04 Sufficient Information	0.538	0.711	0.289	0.121
Item 05 Organisation of Information	0.673	0.547	0.453	0.080
Scale Reliability ($\rho\xi_x$) [b]	0.801			
Goodness-of-fit Measures				
Chi-square (χ^2)	5.778			
Degrees of Freedom (df)	4			
Probability (p)	0.216			
Goodness-of-fit-Index (GFI)	0.993			
Adjusted Goodness-of-fit-Index (AGFI)	0.973			
Root Mean Square Residual (RMR)	0.064			
Root Mean Square Error of Approximation (RMSEA)	0.039			
Normed Fit Index (NFI)	0.935			
Comparative Fit Index (CFI)	0.978			
Incremental Fit Index (IFI)	0.979			
Relative Fit Index (RFI)	0.838			

Notes
a. Proportionally weighted factor score regressions.
b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Attitudes to Computers

Beamish (1988) used the scales developed by Loyd and Gressard (1984) and further developed by Loyd and Loyd (1985) in a study of student attitudes to computers and the factors that affect them. Principal component factor analytic techniques were used to develop the two scales of computer liking and computer confidence. The computer liking scale contained six items and was found to have a Cronbach alpha reliability of 0.89 (N=351). The computer confidence scale contained six items and was found to have a Cronbach alpha reliability of 0.76 (N=351).

The current analysis used LISREL8 to further develop these scales using one-factor congeneric models. The Student Computer Liking Construct and the Student Computer Confidence Construct was computed from the maximally weighted, proportional factor score regression coefficients obtained from one-factor congeneric models. Eleven of the original 14 items (see Beamish, 1988) were found to be significant indicators of the attitude models that were developed.

Table A3.14 Fitted One-factor Congeneric Model for Computer Liking (N=392)

Computer Liking	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 01	0.759	0.424	0.576	0.165
Item 02	0.785	0.384	0.616	0.188
Item 03.	0.814	0.338	0.662	0.223
Item 06	0.797	0.365	0.635	0.201
Item 07	0.784	0.386	0.614	0.167
Item 11	0.628	0.606	0.394	0.057
Scale Reliability ($\rho\xi_x$) [b]	0.902			
Goodness-of-fit Measures				
Chi-square (χ^2)	11.191			
Degrees of Freedom (df)	8			
Probability (p)	0.191			
Goodness-of-fit-Index (GFI)	0.994			
Adjusted Goodness-of-fit-Index (AGFI)	0.985			
Root Mean Square Residual (RMR)	0.025			
Root Mean Square Error of Approximation (RMSEA)	0.032			
Normed Fit Index (NFI)	0.986			
Comparative Fit Index (CFI)	0.996			
Incremental Fit Index (IFI)	0.996			
Relative Fit Index (RFI)	0.975			

Notes
a. Proportionally weighted factor score regressions.
b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Table A3.15 Fitted One-factor Congeneric Model for Computer Confidence (N=386)

Computer Confidence	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 04	0.802	0.356	0.644	0.263
Item 05	0.808	0.347	0.653	0.303
Item 08	0.783	0.387	0.613	0.228
Item 10	0.683	0.534	0.466	0.091
Item 12	0.708	0.499	0.501	0.116
Scale Reliability ($\rho\xi_x$) [b]	0.897			
Goodness-of-fit Measures				
Chi-square (χ^2)	3.962			
Degrees of Freedom (df)	2			
Probability (p)	0.138			
Goodness-of-fit-Index (GFI)	0.997			
Adjusted Goodness-of-fit-Index (AGFI)	0.977			
Root Mean Square Residual (RMR)	0.027			
Root Mean Square Error of Approximation (RMSEA)	0.050			
Normed Fit Index (NFI)	0.989			
Comparative Fit Index (CFI)	0.994			
Incremental Fit Index (IFI)	0.994			
Relative Fit Index (RFI)	0.944			

Notes

a. Proportionally weighted factor score regressions.

b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Knowledge

The Knowledge constructs indicate the level of content knowledge students acquired of the various databases used throughout the course. The Knowledge instrument contains multiple choice items that test for detail, main ideas, and the themes of content areas covered within the database course.

Instruments were developed during the Pilot study to measure student knowledge. The data collected from these instruments were analysed using principal components factor analytic techniques due to the small number in the pilot study sample (N<200). Factor analysis gave a single factor with an eigenvalue greater than one. The factor contained 14 items and the alpha reliability for the scale was found to be 0.69 (N=167).

These scales were further developed using LISREL8 to develop one-factor congeneric models for the measurement of the student knowledge constructs. The High School Knowledge Construct and the Movie Knowledge Construct was computed from the maximally weighted, proportional factor score regression coefficients obtained from one-factor congeneric models. Nine of the original 32 knowledge items were found to be significant indicators of the knowledge models developed.

Table A3.16 Fitted One-factor Congeneric Model for High School Knowledge (N=331)

High School Knowledge	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 01	0.635	0.597	0.403	0.359
Item 02	0.763	0.418	0.582	0.109
Item 07	0.796	0.367	0.633	0.485
Item 09	0.547	0.701	0.299	0.047
Scale Reliability ($\rho\xi_x$) [b]	0.947			
Goodness-of-fit Measures				
Chi-square (χ^2)	2.338			
Degrees of Freedom (df)	1			
Probability (p)	0.126			
Goodness-of-fit-Index (GFI)	0.997			
Adjusted Goodness-of-fit-Index (AGFI)	0.972			
Root Mean Square Residual (RMR)	0.037			
Root Mean Square Error of Approximation (RMSEA)	0.053			
Normed Fit Index (NFI)	0.987			
Comparative Fit Index (CFI)	0.992			
Incremental Fit Index (IFI)	0.993			
Relative Fit Index (RFI)	0.922			

Notes

a. Proportionally weighted factor score regressions.

b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Table A3.17 Fitted One-factor Congeneric Model for Movie Knowledge (N=373)

Movie Knowledge	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 02	0.858	0.264	0.736	0.324
Item 03	0.850	0.277	0.723	0.305
Item 04	0.507	0.743	0.257	0.068
Item 05	0.792	0.372	0.628	0.212
Item 07	0.597	0.644	0.356	0.092
Scale Reliability ($\rho\xi_x$) [b]	0.884			
Goodness-of-fit Measures				
Chi-square (χ^2)	5.707			
Degrees of Freedom (df)	5			
Probability (p)	0.336			
Goodness-of-fit-Index (GFI)	0.995			
Adjusted Goodness-of-fit-Index (AGFI)	0.984			
Root Mean Square Residual (RMR)	0.047			
Root Mean Square Error of Approximation (RMSEA)	0.020			
Normed Fit Index (NFI)	0.967			
Comparative Fit Index (CFI)	0.996			
Incremental Fit Index (IFI)	0.996			
Relative Fit Index (RFI)	0.934			

Notes

a. Proportionally weighted factor score regressions.

b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Database Knowledge

The database knowledge instrument was designed to measure the knowledge that students had of databases and student ability to solve problems using computerised databases. Consequently, the items in the database knowledge instrument covered a range of questions about databases as well as some practical database activities. In the current study, LISREL8 was used to develop a one-factor congeneric model for the measurement of the Database Knowledge construct. Six of the 21 original database knowledge items were found to be significant indicators of the database knowledge model.

Table A3.18 **Fitted One-factor Congeneric Model for Database Knowledge** (N=410)

Database Knowledge	λ_i	θ_i	$\rho\xi_i$	ω_i
Parameter Estimates				
Item 02	0.594	0.641	0.359	0.171
Item 04	0.546	0.702	0.298	0.093
Item 06	0.703	0.503	0.497	0.152
Item 08	0.747	0.457	0.543	0.187
Item 09	0.772	0.394	0.606	0.225
Item 21	0.667	0.562	0.438	0.197
Scale Reliability ($\rho\xi_x$) [b]	0.834			
Goodness-of-fit Measures				
Chi-square (χ^2)	10.224			
Degrees of Freedom (df)	8			
Probability (p)	0.252			
Goodness-of-fit-Index (GFI)	0.991			
Adjusted Goodness-of-fit-Index (AGFI)	0.982			
Root Mean Square Residual (RMR)	0.091			
Root Mean Square Error of Approximation (RMSEA)	0.026			
Normed Fit Index (NFI)	0.917			
Comparative Fit Index (CFI)	0.982			
Incremental Fit Index (IFI)	0.982			
Relative Fit Index (RFI)	0.854			

Notes
a. Proportionally weighted factor score regressions.
b. Estimate of $\rho\xi_x$ obtained from equivalent LISREL7 model.

Appendix 4

Multilevel Models

Appendix 4.1 Significant Within- and Between-Class Variation of Main Study Variables

The within- and between-class variation in the Age, Gender, Computer Experience, Pre-test Information Processing, Post-test Information Processing, Post-test Knowledge-High School, Pre-test Knowledge-Movies, Post-test Knowledge-Movies, and Knowledge about Databases variables are displayed graphically in Figures A4.1 to A4.9. There are 22 horizontal lines in each figure (one for each class). Each horizontal line indicates the distribution of the scores of the variable around the grand mean of the variable. The right hand endpoint of each class line indicates the maximum score in the class while the left hand endpoint of the line indicates the minimum score for the class. If each horizontal class line was extrapolated so that it cut the y-axis, the y-axis intercept would be the class mean. The distribution of lines on the y-axis represents the distribution of class means around the grand mean. Therefore, Figures A4.1 to A4.9 offer a summary of both student and class distributions for included variables in all 22 classes.

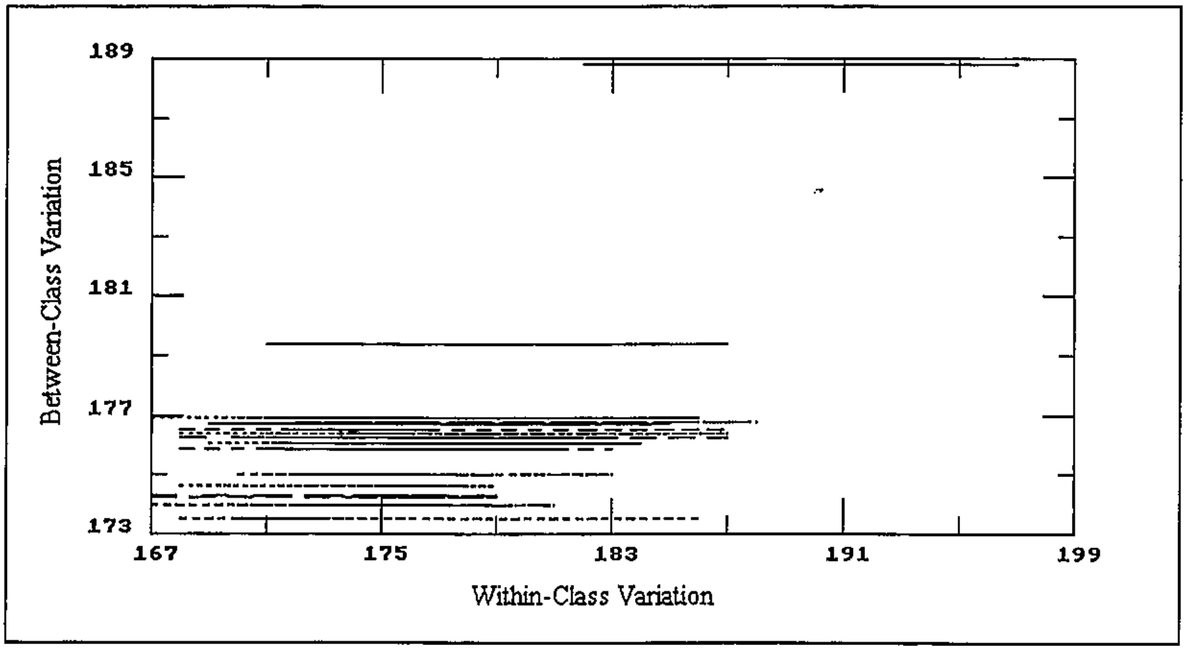

Figure A4.1 **Variation in Student Age**

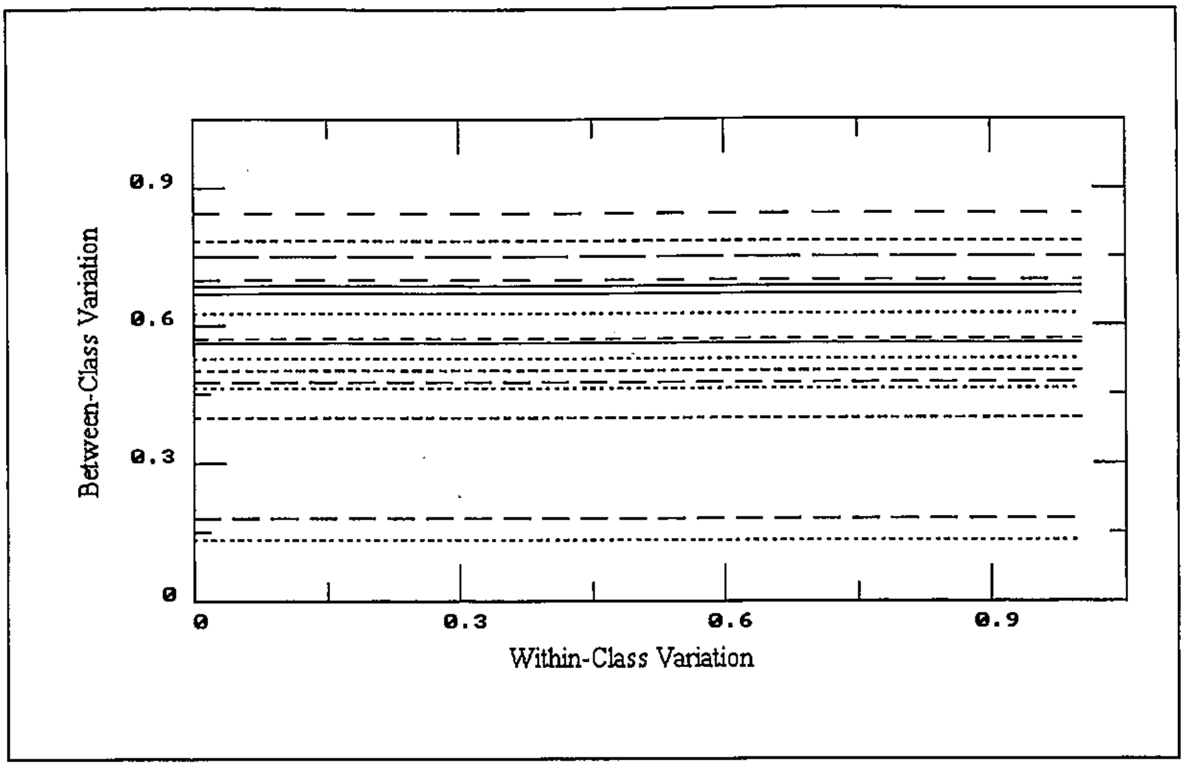

Figure A4.2 Variation in Gender

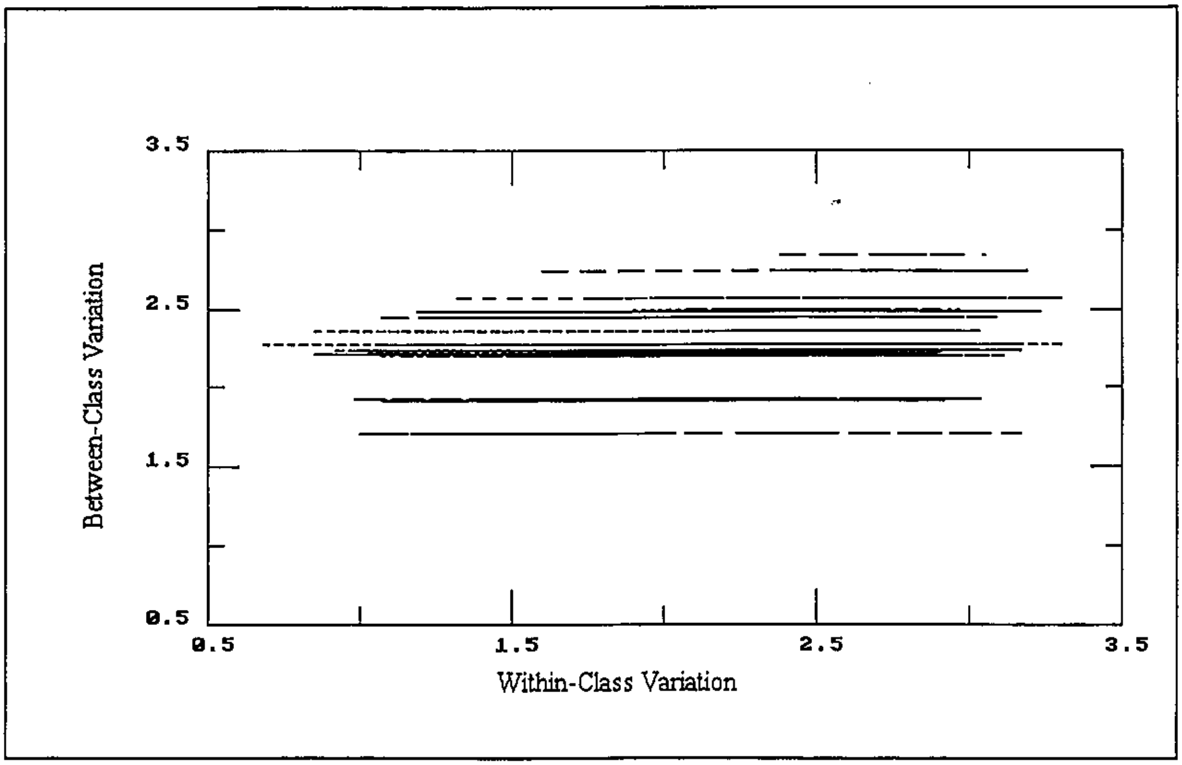

Figure A4.3 Variation in Computer Experience

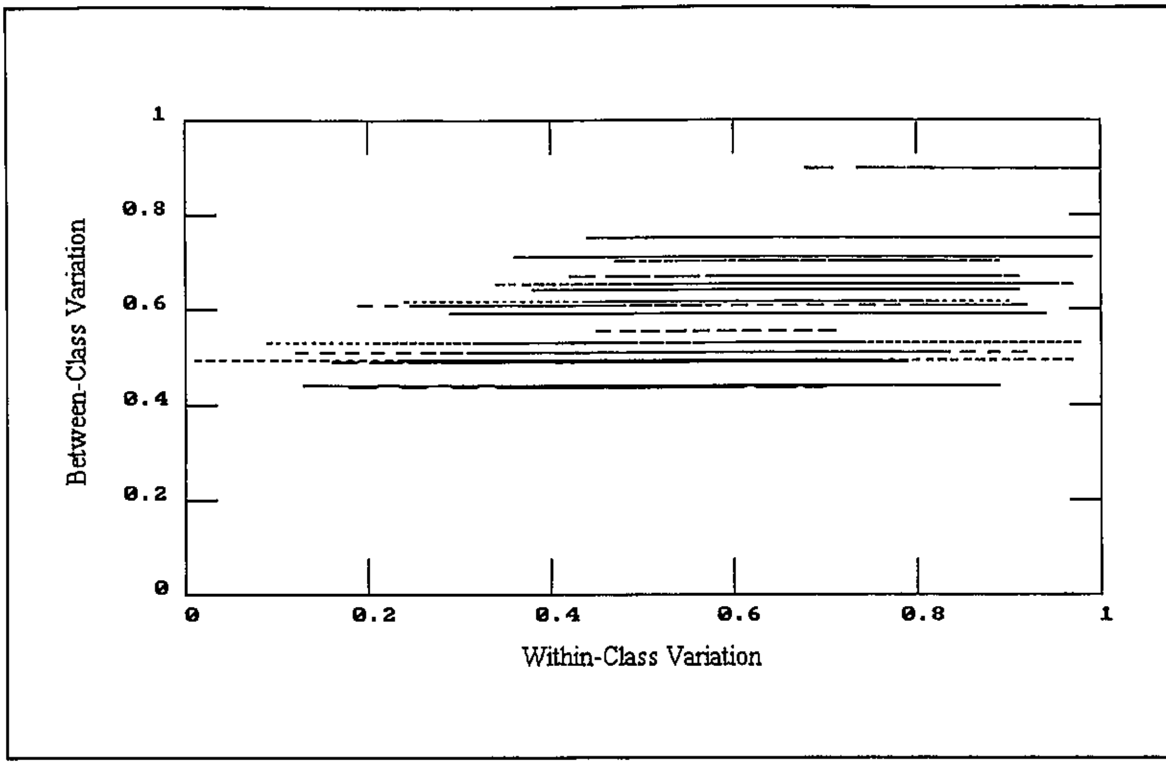

Figure A4.4 **Variation in Pre-test Information Processing**

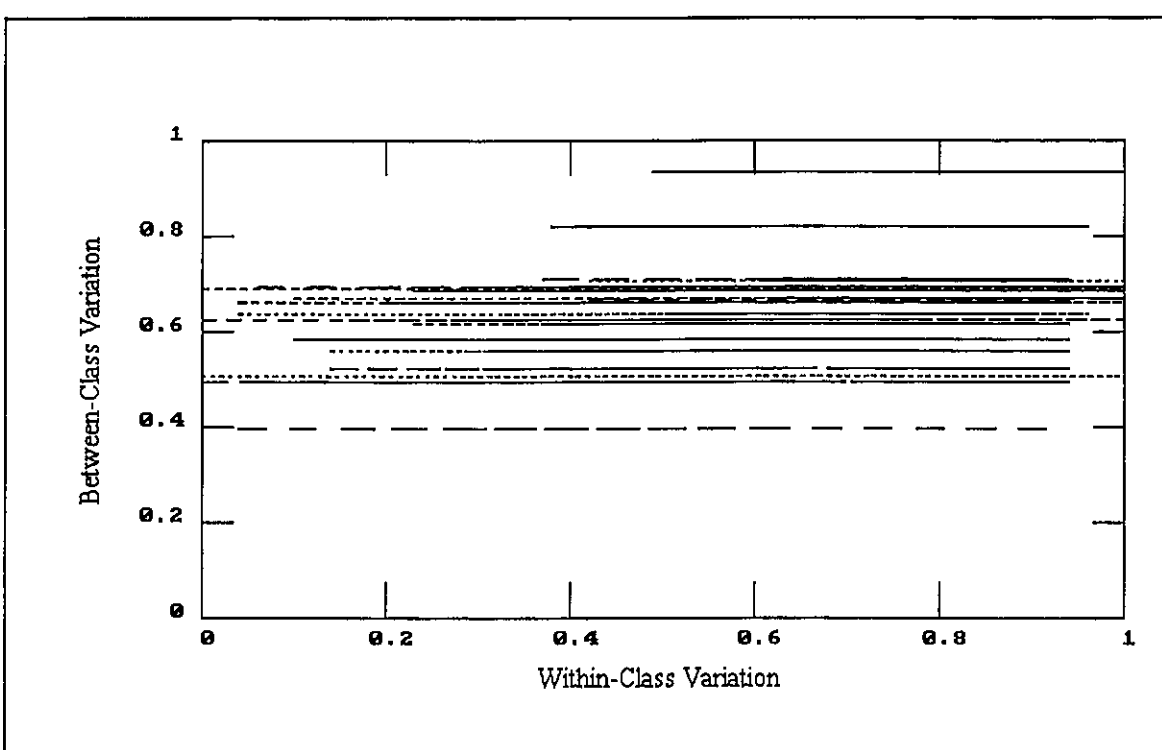

Figure A4.5 **Variation in Pre-test Knowledge-Movies**

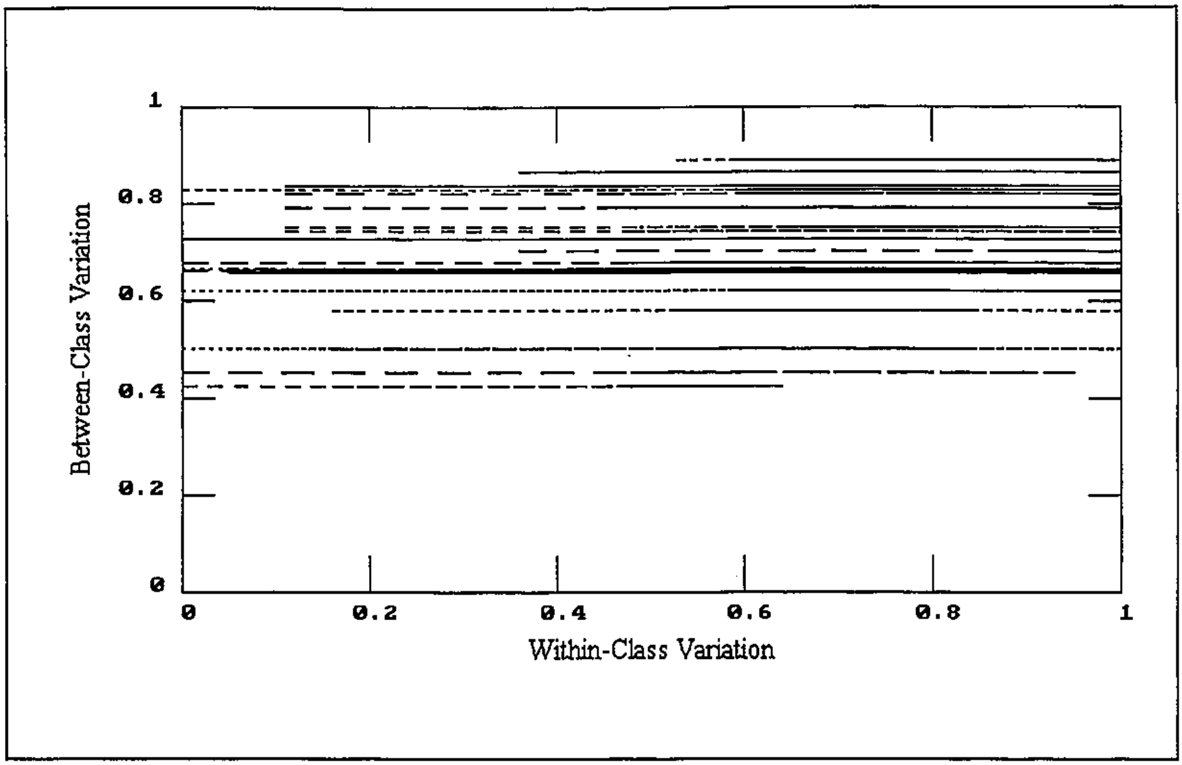

Figure A4.6 Variation in Post-test Knowledge-High School

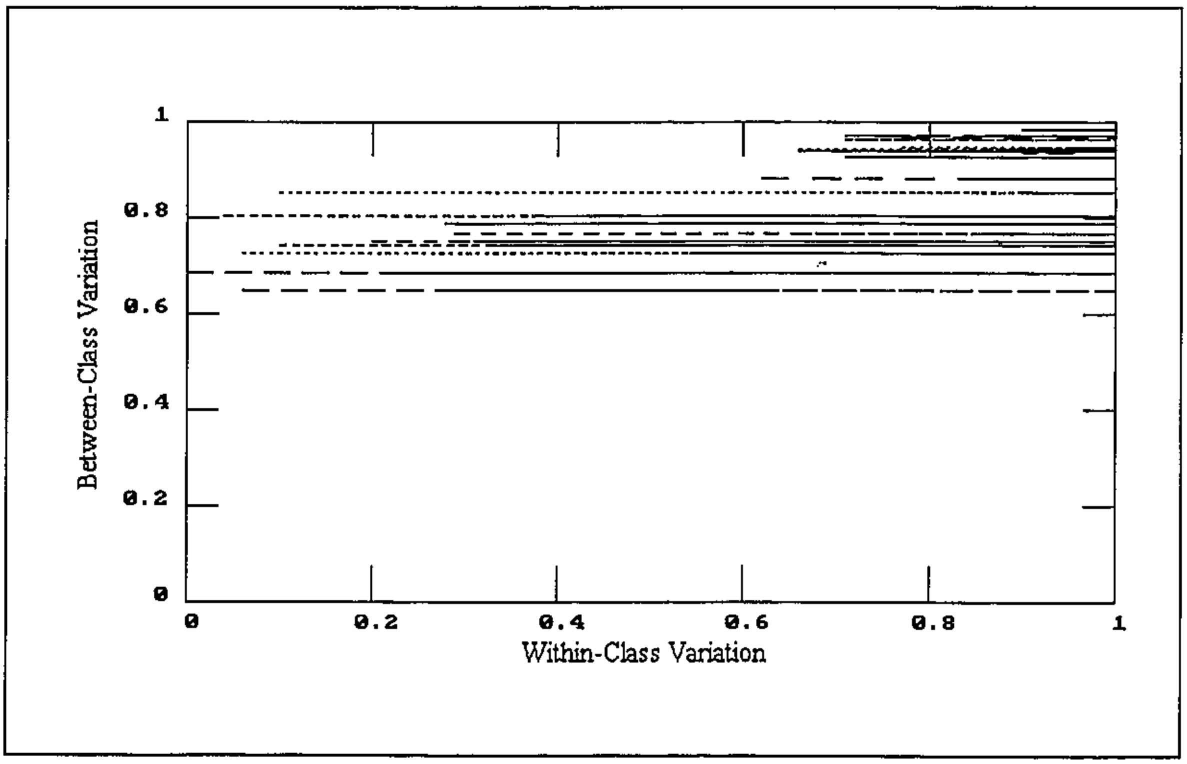

Figure A4.7 Variation in Post-test Knowledge-Movies

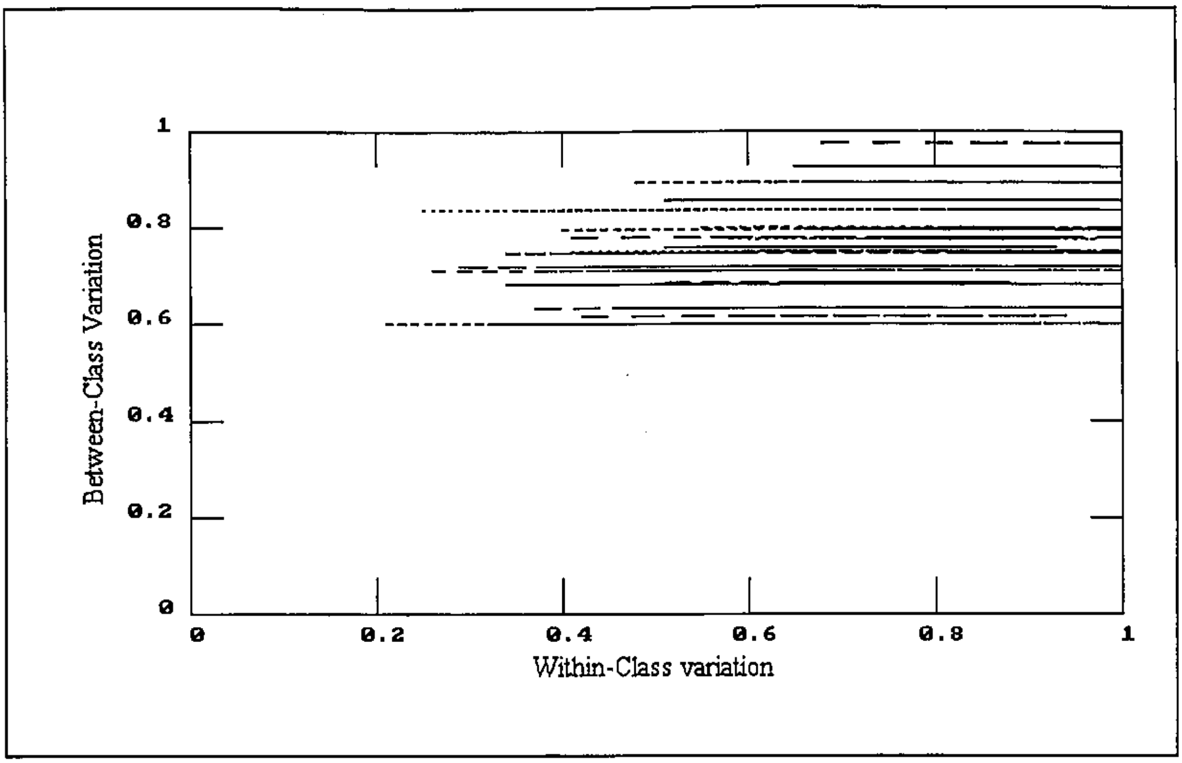

Figure A4.8 **Variation in Post-test Information Processing**

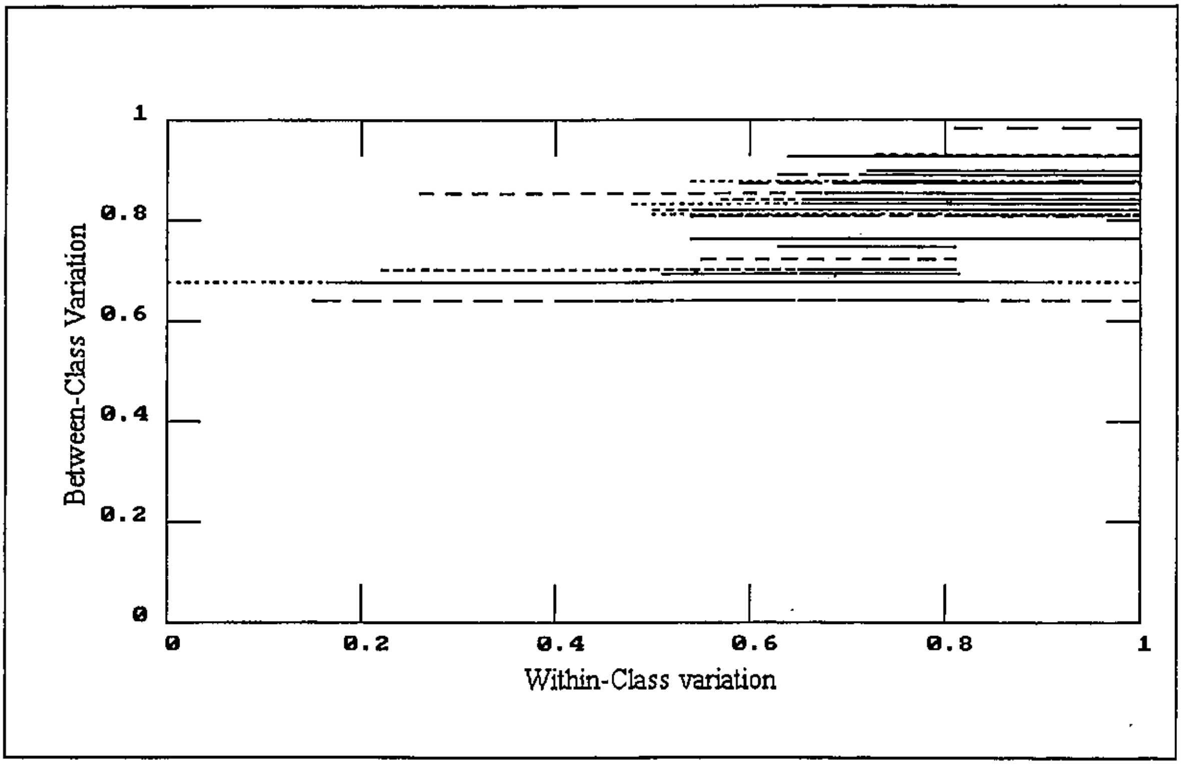

Figure A4.9 **Variation in Knowledge of Databases**

Appendix 4.2 Multilevel Model Equations

Variance Components Models

Rowe, Hill & Holmes-Smith (1995) show how the simple variance components model may be written in two parts:

a within classes part:

$$Y_{ij} = \beta_{0j} X_0 + e_{ij}$$

and a between classes part:

$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$

where Y_{ij} = the outcome (response) variable for students i in class j

$X_0 = 1$; so that no explanatory variable is fitted into the model

β_{0j} = the mean outcome (y-axis intercept) for class j

γ_{00} = the grand mean outcome for all classes

e_{ij} = student-level random residual for student i in class j

μ_{0j} = class-level random residual for class j

So the general form of the two-level variance components model can be written as:

$$Y_{ij} = \gamma_{00} + (\mu_{0j} + e_{ij})$$

The distributional assumptions for the random coefficients are:
$\mu_{0j} \sim$ NID $(0, \sigma_0^2)$, where σ_0^2 is the variance of the level 2 (class) residuals μ_{0j};
$e_{ij} \sim$ NID $(0, \sigma_e^2)$, where σ_e^2 is the variance of the level 1 (student) residuals e_{ij};
and μ_{0j} and e_{ij} are normal and independent (NID).

The total variance of the response variable as calculated is:

$$\text{Var}(Y_{ij}) = \text{Var}(\mu_{0j} + e_{ij}) = \sigma_0^2 + \sigma_e^2$$

Since the random parameters are measured at different levels of the hierarchy they are assumed to be uncorrelated, and the intra-class correlation is given as:

$$\rho = \sigma_0^2 (\sigma_0^2 + \sigma_e^2)^{-1}$$

The intra-class correlation provides an estimate of the proportion of total variance between students that is accounted for by variation between classes.

Multilevel Models

Once the strength of multilevel effects have been established through examination of the variance components model, MLn multilevel regression models are used to consider what proportion of the variance can be accounted for by explanatory variables at each level of the model. Since it is possible for student responses to have a class-specific dimension, regression coefficients can vary randomly at class levels both in terms of the intercepts and regression slopes (Smith, 1996).

Following Smith (1996) it is possible to write a general structural model at each level such that;

at level-1, student outcomes are a function of *p* student-level predictors (A_{pijk}), with regression coefficients (π_{pjk}) plus a random error term (e_{ijk})

$$Y_{ijk} = \pi_{0jk} + \sum_{p=1}^{p} \pi_{pjk} A_{pijk} + e_{ijk}$$

where

Y_{ijk} = the response for child i in class j in school k

π_{0jk} = the intercept for class j in school k

A_{pijk} = p individual characteristics that predict Y_{ijk}

π_{pjk} = are p associated level-1 coefficients indicating the direction and strength of association between each A_p and the outcome in each classroom *jk*

e_{ijk} = the level-1 random effect that represents the deviation of child ijk's score from the predicted score based on the student-level model.

At level-2, where each of the student-level coefficients, including the intercept (π_{0jk}), can be viewed as fixed, non-randomly varying or random, and as being predicted by q classroom characteristics,

$$\pi_{pjk} = \beta_{p0k} + \sum_{q=1}^{Q} \beta_{pqk} X_{qjk} + u_{pjk}$$

where

β_{p0k} = the intercept for school k in modelling the classroom effect π_{pjk}

X_{qjk} = classroom characteristics used as a predictor of the classroom effect π_{pjk}

β_{pqk} = coefficient representing the direction and strength of association between characteristics X_{qjk} and π_{pjk}

u_{pjk} = level-2 random effect that represents the deviation of class jk's level-1 coefficient (π_{0jk}) from its predicted value based on the classroom level model

and level-3 outcomes may be predicted by s school level characteristics

$$\beta_{pqk} = \gamma_{pq0} + \sum_{s=1}^{Spq} \gamma_{pqs} W_{sk} + v_{pqk}$$

where

γ_{pq0} = is the intercept term in the school level model for β_{pqk}

W_{sk} = a school characteristic used as a predictor for the school effect β_{pqk}

γ_{pqs} = level-3 coefficients that represent the direction and strength of association between the school characteristic W_{sk} and β_{pqk}

v_{pqk} = level-3 random effect that represents the deviation of school k's coefficient β_{pqk} from its predicted value based on the school-level model.

Appendix 5

Organisation and Administration of the Study

N.S.W. Government Offices
117 Bull Street
Newcastle West 2302
P.O. Box 488G
Newcastle 2300
Our Ref:
Your Ref:
Telephone: (049) 255755
(Direct Dial):
Fax: (049) 255701

Hunter Region

Mr Peter Beamish
12 Woodside Drive
ELEEBANA NSW 2282

Dear Peter

At the meeting of the Hunter Region Research and Evaluation Committee on 20th May 1994, your research proposal titled "attempting to clarify those factors that affect the use of computers as information processing tools when programmed with a database package", was considered and approved.

No changes were recommended by the committee. You will appreciate that you will need the concurrence of the parents and the principal to carry out your research.

You may wish to photocopy this letter and include it with any written communication with the nominated schools in your research proposal. You are reminded that the ultimate authority regarding conduct of research in schools remains with the principal.

The committee requests that you submit a report upon completion of your research.

Should you have any further questions or would like additional information please contact me on (049) 255798.

Yours sincerely

Col Elliott

COL ELLIOTT
Assistant Regional Director
Teaching and Learning

25 May, 1994

Appendix 5.2

Dear School Principal,

I am conducting research into how students learn when using computers. The research project looks at which ways of learning are most effective.

I would like your school to be part of this research project. The study is to take place within the Year Nine Computing Studies Course in Term 3 of 1994. Students will be asked some questions about using computers and then they will work on computers during the term in their Computing Studies classes. This project will take no extra time and the lessons during the term cover material that is within the Computing Studies syllabus.

Anything the students tell us about their learning will not be passed on to anyone else. It will be confidential. Results will be reported in general terms and neither student nor school will ever be identified.

I have made an initial approach to the Year Nine Computing Studies teachers in your school and they would like to be part of the project. I am hopeful that you will give permission for this study to proceed in your school.

The study has the full approval of the Department of School Education, and I am including with this letter a copy of that approval. I am also including a copy of the application that was sent to the Department of School Education as it gives summary information about the project.

If you would like any further information about the project, please feel free to phone me on 468405.

Thank you for your consideration in this matter,

Peter Beamish

Appendix 5.3

CONSENT TO PARTICIPATE IN RESEARCH
Information Statement

Dear Student and Parents,

Computers are becoming more and more a part of modern life at home, school, and work. We are doing research into how students learn when using computers. The research project looks at ways that computers can be used to assist students in their learning.

The school principal and teachers have kindly agreed to support this project. We wish to seek your cooperation to be part of the study. To do this students will be asked some questions about using computers and then their class will be observed while they work on computers in their Computing Studies classes.

Anything they tell us about their learning will not be passed on to anyone else. It will be confidential. Results are to be used in the postgraduate research of the researcher and will be reported in general terms and neither students nor schools will ever be identified.

This project will take no extra time and the lessons cover material that is within the Computing Studies syllabus.

If you and your parents agree to help us in the project, could you both please complete the attached reply slip and return it to your teacher at school tomorrow.

Thank you.

PETER BEAMISH
Researcher

Dr WING AU
Supervisor

The University requires that all participants are informed that if they have any complaint concerning the manner in which a research project is conducted it may be given to the researcher, or if an independent person is preferred, to the University's Human Research Ethics Officer, Office for Research, Chancellery, University of Newcastle, 2308, (Telephone 216333).

....

I agree to participate in the project on the use of computers in schools.

Name...

Student's
Signature...

I agree for my child to participate in the project on the use of computers in schools.

Parent's
Signature...

Appendix 5.4

Dear «Teacher First Name»,

Thank you for agreeing to be part of the Year 9 Computing Studies project in term three of this year. Currently, twelve schools, twenty teachers, and approximately five hundred students will be working together during this study.

This is a reminder about the briefing session for teachers that is to be conducted at the University of Newcastle tomorrow night (Tuesday June 21) from 7:00 to 8:00 pm. This session is important for all teachers who will be involved in the study as aspects of the database lessons and project will be explained. Teachers will also be able to collect their books containing the lessons for the term and there will be time to answer any questions that teachers may have.

The briefing session will be conducted in room C102. This room is in the Hunter Building (The old CAE end of the University). To find the room, enter the building through the double glass doors near the Griffith Duncan Theatre. Make your way down the large corridor until you pass the Huxley Library on your left. At this point there is a corridor that runs off to the right. Walk down this corridor and go down the first set of steps on your left. Upon reaching the bottom of the steps, turn right, and then right again into the first corridor. Room C102 is the first room on your left. (Although this sounds complicated, there are blue signs directing you to the room once you enter the corridor opposite the library.)

During my visit to your school I noted a number of details. They are found below. If any of these are incorrect or missing, please ring me on 018-955631 and I will correct them before the briefing time.

School Name:	«School»
Contact Teacher:	«Teacher»
Other Teachers Involved in the Project:	«Other Teachers»
Number of Classes:	«Classes»
Total number of students:	«No. of students»
Classroom Platform:	«Platform»
Classroom Software:	«Software»
School Phone Number:	«School Phone Contact»
School Fax Number:	«School Fax. Contact»
Home Phone Number (Optional):	«Home Phone Contact»

Thank you for your help and cooperation in these matters:

Peter Beamish

Appendix 5.5

Teacher Briefing Session

Program Outline

1. Introduction and Welcome

2. Importance of computers in society

3. The use of databases in the classroom

4. A general model of databases and learning

5. The database course

   Course objectives:

   - database specific strategies
   - content knowledge
   - cognitive strategies
   - metacognitive strategies

   Database lesson details

   Student materials

   Testing instruments and assessment tasks

   Classroom observations

   Computer hardware and software

6. Logistics:

   - Application to Department of Education
   - Principals to Principals
   - Letters of consent

Appendix 6
Pilot Study Analysis

The data collected from students involved in the pilot study were analysed using principal components factor analysis and alpha reliability testing (SPSS Inc., 1993). T-tests were used to establish that there was no significant differences between the schools and that they could be included as a single unit in the analysis. The factor loadings for the retained items in each of the scales are found in their respective tables. Items were discarded if they failed to load on the appropriate factor for which they were designed, or load on more than one factor.

Table A5.1 Pilot Database Course[1]

Week 1	Introduction Lesson	Instrument 1	Database Terminology	Instrument 2
Week 2	Instrument 3	Browsing /Layout /Arranging	Browsing /Layout /Arranging	Arranging / Sorting
Week 3	Selecting Records (find)	Selecting Records (find)	Selecting Records (find)	Selecting Records (find/sort)
Week 4	Hypothesis Testing High School Database	Hypothesis Testing High School Database	Hypothesis Testing High School Database	Hypothesis Testing High School Quiz
Week 5	Hypothesis Testing World Database	Hypothesis Testing World Database	Hypothesis Testing World Database	Hypothesis Testing World Quiz
Week 6	Hypothesis Testing Movie Database	Hypothesis Testing Movie Database	Building a Datafile	Building a Datafile
Week 7	Building a Datafile	Building a Datafile	Instrument 4	Instrument 5

[1] A full copy of the database course (as used in the main study) including all lesson outlines and worksheets is found in Appendix 1.

Factor Loadings for Scales Trialed in the Pilot Study

Information Processing Scale

Factor analysis gave a single factor with an eigenvalue greater than one. The factor contained 23 items and the alpha reliability for the scale was found to be 0.84 (n=198).

Table A5.2 Factor Loadings for Information Processing Scale

Item Number	Factor Loading	Item Number cont..	Factor Loading cont..
O7	.59	S1	.45
H5	.59	O6	.43
H1	.56	O5	.43
S6	.56	R5	.42
R1	.56	I1	.41
R2	.53	S2	.39
I6	.52	O2	.38
H3	.52	I5	.38
O4	.49	I3	.37
I4	.47	S4	.37
H2	.46	O1	.34
H6	.45		

Knowledge Scale

Factor analysis gave a single factor with an eigenvalue greater than one. The factor contained 14 items and the alpha reliability for the scale was found to be 0.69 (n=167).

Table A5.2 Factor Loadings for Information Processing Scale

Item Number	Factor Loading
HS4	.70
M2	.55
W8	.47
W9	.45
M4	.45
M6	.44
W10	.41
M7	.39
HS3	.37
HS9	.36
W6	.35
M9	.32
M5	.32
HS7	.27

Student Flexibility Questionnaire

Factor analysis gave two factors with an eigenvalue greater than one. The first factor (Adaptive) contained 7 items and the alpha reliability was found to be 0.82 (n=152). The second factor (Maladative) contained 13 items and the alpha reliability was found to be 0.79 (n=152).

Table A5.2 Factor Loadings for Student Flexibility Scales

Item Number	Factor 1 Loading	Factor 2 Loading
Adaptive 1	.51	
Adaptive 2	.75	
Adaptive 3	.63	
Adaptive 4	.69	
Adaptive 5	.63	
Adaptive 6	.74	
Adaptive 7	.55	
Irresolute 1		.61
Irresolute 2		.45
Irresolute 3		.43
Irresolute 4		.59
Irresolute 5		.62
Irresolute 6		.63
Irresolute 7		.61
Inflexible 2		.59
Inflexible 3		.62
Inflexible 4		.47
Inflexible 5		.66
Inflexible 6		.54
Inflexible 7		.61