Authentic learning
in interactive multimedia environments

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Abstract

The instructional technology community is in the midst of a philosophical shift from a behaviourist to a constructivist framework, a move that may begin to address the growing rift between formal school learning and real-life learning. One theory of learning which has the capacity to promote authentic learning is that of situated learning.

The purpose of the study was to investigate the way students learn from an interactive multimedia package and learning environment based on a situated learning model. To do this, it was necessary to identify the critical characteristics of a situated learning model based on the extensive literature on the subject. An interactive multimedia learning environment for university level students was then designed according to these characteristics of a situated learning model. The learning environment comprised an interactive multimedia program on assessment in mathematics, together with recommended implementation conditions in the classroom. Specifically, the research sought to investigate the way preservice teachers used interactive multimedia based on a situated learning model, how they responded to the critical elements of the situated learning environment, what types of higher-order thinking they used as they worked with the program, and whether learning transferred to their professional teaching practice in schools.

The research took the form of an interpretive, qualitative study. The major methods of data collection were videotaping of preservice teachers using the interactive multimedia program, observation, and interviews with both the preservice teachers and their supervising teachers in schools. Data was analysed using techniques of qualitative analysis recommended by Eisner (1991) and Miles and Huberman (1994).

Findings suggest that the use of the situated learning model was a successful alternative to the system models frequently used for the development of interactive multimedia, and one that enabled students to freely navigate a complex resource. When implemented with all the characteristics defined in the model, it appeared to provide an effective framework for the design of an environment for the acquisition of advanced knowledge. Students used a substantial amount of higher-order thinking,

relatively little social and lower order talk, and a moderate amount of procedural talk as they worked with the assessment program. While on their professional practice in schools, the students used a variety of assessment techniques to assess children's learning, and they were able to speak knowledgably and confidently about the issue of assessment, supporting the view that they had incorporated their learning deeply into their cognitive structures. According to the beliefs of the students themselves, the multimedia program appeared to influence the types of strategies they employed and their thinking about assessment as they taught mathematics and other classes during their professional practice.

The major implication of the research is that new learning theory *can* inform the instructional design of interactive multimedia. For implementation in contexts of advanced knowledge acquisition, an instructional design model based on situated learning is an effective substitute for the traditional instructional systems model. Further implications are that excessive intervention by the developer in providing interaction between the program and the learner is not necessary, and that multimedia materials are best designed and implemented socially, not as independent instruction for individual learners. At the conclusion of the thesis, extensive recommendations for further research, both systemic and analytic, are provided.

Declaration

"I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any institution in higher education; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text."

Signed:

Date:

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I dedicate this work to my father, John Maxwell Parkinson (1921-1991) who in his life had just eight years of schooling, but seventy years of learning.

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Introduction

Background to the study

Throughout the history of education, teachers and educators have sought to use pedagogical methods that ensure students learn efficiently and effectively in classroom settings. Decades of research and speculation have produced numerous programs and recommendations ranging from the bizarre (e.g., heated clothing to keep students at the most comfortable temperature for learning, Morgan, 1997) to the controversial (e.g., the use of drugs to enhance cognitive function, Lawton, 1997). Thousands of research studies and hundreds of meta-analyses have been conducted to try to determine those elements of instruction that are effective and worth adopting in a discipline that offers countless competing schemes and plans. Meta-analyses of meta-analyses have been conducted (e.g., Hattie, 1992 who combined the results of 134 meta-analyses to gauge the effects of schooling) in the quest to find the meaning of what is truly critical in pedagogy.

When an educational community is sufficiently convinced that a philosophy or paradigm for learning has promise, years of educational thought and innovation can develop according to its principles. The field of instructional technology, for example, has shown a strong tendency to attempt to use 'the confluence of research, technology and systems' (Shrock, 1991, p.18) to effect educational change and increase the effectiveness of instruction. Shrock (1991), in an article on the history of instructional technology has nominated the predominant influences of thought and development in each of the decades since the early part of this century, influences such as behavioural objectives in the 1930s, programmed instruction, instructional systems development in the 1960s, and microcomputers and performance technologies in the 1980s. Many of these developments have been predicated on the belief that new technologies are integral to more effective learning, and they have been promoted on these claims.

However, rapid and widespread adoption of the newest and fastest technology has been shown to present problems for the educational community. Unless careful thought is given to how these technologies can be used most effectively in the teaching program,

the result can be the 'new technology in the cupboard' syndrome (Wilson, R. 1996). The history of educational technology is littered with the unfulfilled promises of technology. Cuban (1996) lists as casualties: radio in the 1920s, film projectors in the 1930s, and instructional television in the 1950s. He points out that the latest technology is frequently adopted with great enthusiasm as the panacea to educational problems, only to be rejected when the exaggerated claims for its capabilities are unfulfilled.

When desktop computers were introduced in the late 1970s, and when multimedia capabilities emerged in the 1980s, similar exaggerated claims were made. Bold claims have been made by writers such as Papert (1980; 1996) and Perelman (1993; 1997) that new technologies effectively undermine the necessity for schools. While there has been no indication yet of their imminent demise, many universities and tertiary institutions have seized upon the potential of computers to provide low cost teaching in times of cutbacks and reduced budgets (Zevenbergen, 1996), and as a means to promote more flexible, less teacher-dependent modes of learning (Maslen, 1997). The adoption of computer technology in schools has proceeded at a steady pace, (for example, all Australian states have programs in progress to enable all state schools to have access to the Internet) but many believe that its impact has been minimised by inappropriate use. For example, Rogers (quoted in Wilson, R. 1996) has stated that: 'You could walk into 80% of the classrooms in the US and, I'm sure, Australia, and find that the computers have not changed education at all' (p. 11). He attributes this lack of success to the tendency for computers to be 'used as teaching machines'.

Clearly, computers per se cannot improve the effectiveness of learning in classrooms. If computers are not to be the next 'technology in the cupboard', their adoption and use must be reassessed. It is useful to consider this reexamination within the context of a wider dissatisfaction which has recently emerged with the basic concept of school-based education itself, a discussion of which follows in the next section.

School-based and real-life learning

Since the late 1980s, in particular, there is much argument in the literature that schools and universities are lacking in their ability to produce students who can think creatively, who can solve problems and who can use the knowledge they have acquired in appropriate and adaptive ways. Students' abilities to think and reason are not being developed, and the culture of classrooms promotes superficial rather than deep learning (Cognition and Technology Group at Vanderbilt, 1993c).

Resnick (1987b) contends that school learning is fundamentally different to everyday, practical learning in several distinct ways. School learning largely promotes individual endeavour and cognition, and yet activity outside school is predominantly shared. School learning concentrates on promoting 'pure thought' and abstract representations rather than the effective use of tools (such as calculators, notes, and books) as is preferred outside. Symbol manipulation, favoured in school learning, is largely rejected outside where actions are closely connected to the actual context of objects and events. Finally, school learning promotes generalised, theoretical principles and skills rather than the situation-specific capabilities outside. These differences between formal and real-world learning are not only evident in schools. Any form of teaching or training is inadequate where trainees are removed from authentic situations and given instruction which adheres to a traditional classroom model. Universities, corporate management training, teacher training and military training programs have all suffered from too little engagement with genuine situations, and too much emphasis on theoretical perspectives (Resnick, 1987b).

Sternberg, Wagner and Okagaki (1993) analyse the differences between the kinds of problems learners face in academic situations and practical, real-world applications. For example, academic problems tend to be: formulated by others, well-defined, complete in the information they provide, characterised by having only one correct answer, characterised by having only one method of obtaining the correct answer, disembedded from ordinary experience, and of little or no intrinsic interest. In direct contrast to the academic approach, practical problems tend to be characterised by: the key roles of problem recognition and definition, the ill-defined nature of the problem, substantial information seeking, multiple correct solutions, multiple methods of obtaining solutions, the availability of relevant prior experience, and often highly motivating and emotionally involving contingencies (Sternberg, et al., 1993, p. 206). These key differences between the school-based approach and real life have been summarised by Lebow and Wager (1994) (see Table 1.1).

Table 1.1:   Real-life versus in-school problem solving (Lebow & Wager, 1994)

Real-life	In-school
1. Involves ill formulated problems and ill structured conditions.	1. Involves 'textbook' examples and well structured conditions.
2. Problems are embedded in a specific and meaningful context.	2. Problems are largely abstract and decontextualized.
3. Problems have depth, complexity and duration.	3. Problems lack depth, complexity, and duration.
4. Involves cooperative relations and shared consequences.	4. Involves competitive relations and individual assessment.
5. Problems are perceived as real and worth solving.	5. Problems typically seem artificial with low relevance for students.

According to many of these writers, traditional school and university learning is in danger of becoming isolated, irrelevant and marginalised from mainstream real-world activity and performance. The principal task of schools and universities can no longer be the simple transmission of a body of knowledge packaged into discrete subject areas, but the much more challenging task of producing 'adaptive learners' who can respond effectively to changing demands and unpredictable circumstances (Resnick, 1987b, p. 18). Brown (1994) argues that school practices continue to ignore contemporary learning theory in preference to 'outmoded theories of learning that are relics of psychology's behavioristic past' (p. 11).

Theory reflected in interactive multimedia

The theory used in the design of many recently published instructional materials and educational products has also been challenged. As Duffy and Jonassen (1991) point out, theory is integral to the instruction that is produced, and the finished product clearly reflects the theory used. Yet the theory reflected in many contemporary educational programs reflect the 'outmoded theories' of decades ago. For example, many examples of interactive multimedia programs available today follow a format such as the following:

1.   A question or problem of some sort is displayed.

2.   The student is required to respond actively, for example, by constructing or selecting an answer.

3.   Feedback, such as praise for a correct answer or correction of an error is immediate.

4. Errors are minimised by presenting material in small steps, and techniques of prompting, fading, shading and chaining are used.

5. Students are free to work at their own pace.

This model is not a product of recent learning theory. It is the format used by Skinner in the 1950s for programmed instruction used with early teaching machines (Farnham-Diggory, 1992; Case & Bereiter, 1984), a model now consistently challenged within mainstream theory in teaching and learning but still prevalent in multimedia design today. Von Glasersfeld (1995) provocatively states: 'Behaviourism is *passé* as a movement, but some of its central notions are still very much alive, both in psychology and education' (p. xiii).

Spender (1995; 1994) argues that multimedia is at present undergoing the same inertia that plagued print. She points out that the printing press had existed for some 200 years before the birth of the novel. With all new technology, the technology itself becomes the primary focus of interest, not what can be done with it. Spender argues that the medium is still in the hands of the technologists, and until it is placed in the rightful hands of the creative artists and writers (and, one might argue, the teachers), it will not be used in the most effective way. Many designers of educational multimedia, dazzled by the possibilities the technologies offer, revert to the comfortable old theories and models that can be thoughtlessly applied. In multimedia development, Park and Hannafin (1993) believe that technological capacity and the intuition of designers are driving the design of multimedia rather than research and theory. Lebow (1993) contends that the new technologies are forcing teachers and instructional designers to rethink their approach to learning environments because they are in danger of persevering with frameworks and models that are rapidly becoming obsolete.

The challenge is for educators to align formal school learning more substantially with the way learning is achieved in real-life settings, and to base instructional materials design on more recent theories of learning which reflect this shift. One method which has the potential to achieve this is the theory of *situated cognition* or *situated learning*.

Situated cognition and constructivist perspectives

Until the invention of schools, nearly all formal knowledge and skill was transferred through apprenticeships (Collins, 1988). Agricultural skills, trades, medicine, law and the arts were all taught by the master who handed on the required skills to the apprentice (Collins, Brown, & Newman, 1989). In the mid-to-late nineteen eighties, teachers and researchers in education began to investigate the notion of

apprenticeships and to try to distinguish those characteristics which were critical to its success. Their aim was to begin the process of developing a theoretical perspective for learning based on the apprenticeship model, that cognitive science had, to date, not been able to explain. Brown, Collins and Duguid (1989b) were the first to use the ideas to produce a proposal for a model of instruction that has implications for classroom practice. In their model of situated cognition, Brown et al. (1989b) argue that meaningful learning will only take place if it is embedded in the social and physical context within which it will be used. Collins (1988) defines situated learning as: 'the notion of learning knowledge and skills in contexts that reflect the way the knowledge will be useful in real life' (p. 2).

Situated learning as a model of instruction has grown out of a general theoretical shift within the educational community from 'behavioral to cognitive to constructivist' learning perspectives (Ertmer & Newby, 1993, p. 50; von Glasersfeld, 1995; Jonassen, 1991c; Lebow, 1993). While some challenge the notion that situated learning can be classified as a constructivist approach (cf., Cobb, 1994; Anderson, Reder, & Simon, 1995), there is widespread acceptance of its compatibility within the instructional technology literature. While the majority of these writers do not acknowledge 'constructivist instruction'—one paper claims that such a term is an oxymoron (Jonassen, Davidson, Collins, Campbell, & Bannan Haag, 1995)—most believe that some models of instruction could embody much of the constructivist philosophy. For example, Jonassen (1991c) gives situated learning as an example of an application of constructivism, and recent books on constructivist learning environments routinely include situated learning (e.g., Wilson, B. 1996; Duffy, Lowyck, & Jonassen, 1993).

Jonassen (1994) looked at the views of constructivists and instructional designers involved in the debates published in two special editions of *Educational Technology* on constructivism in 1991. From these papers, he concluded that many of the authors believed that knowledge construction may best be facilitated by learning environments which:

- provide multiple representations of reality, which avoid oversimplification

- focus on knowledge construction, not reproduction

- present authentic tasks (contextualising rather than abstract instruction)

- provide real world, case based learning environments rather than pre-determined instructional sequences

- foster reflective practice

- enable context- and content-dependent knowledge construction

- support collaborative construction of knowledge through social negotiation, not competition (p. 35).

Such a definition of a constructivist learning environment in no way excludes situated learning, and the position has been taken in this thesis that situated learning is compatible with a constructivist philosophy.

The move towards constructivist perspectives in instructional technology shows much promise in shifting the focus of instructional materials to a model which is socially and culturally situated, and related more to learning in real life than learning in the classroom. Interactive multimedia is a relatively recent technology that has, to date, been largely based on behavioral theory. The aim of this research has been to investigate the usefulness of a situated learning model as the framework for the design of interactive multimedia—a recent technology paired with a recent theory.

The research questions and studies

The purpose of this research was to determine the effectiveness of a model of instructional design based on the theory of situated learning, and applied to the design of an interactive multimedia learning environment at second year university level. The research was designed to be conducted in five interrelated stages.

Part A: Definition of critical characteristics of situated learning and development of framework

The first stage of the research was to identify the critical characteristics of a situated learning model from the research, debates and discussion generated in the extensive body of literature. The elements identified in this phase of the study provided a framework for the design of an interactive multimedia program which was developed in Part B of the study.

Part B: Design and production of interactive multimedia package

In Part B of the study, a complete instructional package was designed to incorporate the critical elements of a situated learning environment determined in Part A of the research. An interactive multimedia program for CD-ROM was developed in the area of assessment strategies for mathematics teachers of grades K-12, together with planned

strategies for implementation in a second year tertiary mathematics method class. The program was used with students in Parts C and D of the study.

Part C: Pilot study

A pilot study was conducted to determine the feasibility of the proposed research design, to identify any problems, and to begin the process of developing a classification scheme to analyse the student interactions, with particular emphasis on cognitive processes and the relative influence of the critical characteristics defined in Part A. The information provided in this stage of the study enabled further refinement of the multimedia program as well as refinement of the methodology used for Part D of the study.

Part D: The implementation of the interactive multimedia program as a situated learning environment

Part D of the research investigated the use of the interactive multimedia program on assessment techniques designed as a situated learning environment. The study examined students' use of the program in their normal classroom environment, with particular interest in their use of higher-order learning while using the program, and the relative influence of the critical elements of the situated learning environment. Specifically, Part D sought to answer the following questions:

Research question 1: *How do students use an interactive multimedia program designed to incorporate the characteristics of a situated learning environment?*

Research question 2: *How important to students is each of the critical characteristics of situated learning in the interactive multimedia learning environment?*

Research question 3: *What types of higher-order thinking do students employ while using an interactive multimedia program based on principles of situated learning?*

Part E: The transfer study

The transfer study was designed to investigate the extent of the preservice teachers' use of the assessment techniques featured in the interactive multimedia program, in their professional practice in schools. This part of the research sought to answer the following question:

Research question 4:   *How effective is an interactive multimedia program based on principles of situated learning in promoting transfer of knowledge to classroom practice?*

The organisation of the thesis

Throughout the thesis certain conventions and styles have been adopted as guidelines for language, spelling and referencing, and these are described, together with notes on terminology, in Appendix 1.

The thesis begins with a review of the literature which is presented in Chapter 2. It provides a critical reading of the principal theorists (and critics) of situated learning and reveals a number of important characteristics which have added to the evolving theory. The chapter concludes with a list of critical elements which characterise situated learning and provide the basis for the framework of an instructional design model.

Chapter 3 begins with a discussion of each of the critical characteristics of situated learning identified in Chapter 2 and defines those design characteristics in more detail. The literature review then continues by focusing on each of these characteristics in its own right, and this is to capitalise on the findings to be found in the broader body of educational research. Each section concludes with a specific checklist of items that need to be provided in the situated learning environment designed for implementation in the study. The chapter concludes with the research questions, which have been formulated from the findings and implications of previous research in the field.

Once the critical characteristics for a situated learning environment, and guidelines for their implementation, were established, the next stage was to develop an interactive multimedia learning environment which embodied the critical elements of the model. Chapter 4 describes the process of developing the program and designing its implementation in the classroom.

Chapter 5 begins with a literature review of the research methodology used in the study, with justification for its choice. The research methodologies of the five parts of the study are described in detail, together with ethical considerations and a summary of the methods used to ensure reliability and validity of the research.

Chapters 6–9 present the analysis of data and discussion of each of the research questions. Chapter 6 describes the findings of an investigation into how the students used the multimedia software. Chapter 7 reports the findings of the investigation into

situated learning as a model for the design of interactive multimedia: students' awareness of the nine characteristics, how important they are to students, and their beliefs and opinions about the impact of these features on their learning. Chapter 8 investigates whether students employed higher-order thinking as they used the interactive multimedia program. This discussion includes a description of the methodology used to develop the framework for analysis of data from the transcripts of the videotapes. A classification scheme for analysing student talk is described. Chapter 9 provides analysis and discussion of the transfer study. It reports the types of assessment strategy used by each student in the study on their professional practice, and discussion of issues and themes which emerged from analyses of the data.

Chapter 10 presents a summary of the research, together with limitations of the study and recommendations for further research.

Situated cognition: A review of the literature

Inert knowledge

The separation between knowing and doing has traditionally been the hallmark of school and university learning (Resnick, 1987b). The emphasis in school and university has traditionally been on extracting essential principles, concepts and facts, and teaching them in an abstract and decontextualised form. The inadequacies of this approach abound in everyday experience, for example: the driver with a physics degree, attempting to dig the car out of sand instead of partially deflating the tyres; or the cricket spectator who can mentally calculate complex combinations of overs, runs, and remaining balls, but cannot do a simple algorithm with pencil and paper. In cases such as these, there is a failure to access knowledge which is clearly relevant to solve the problem in hand. Information has been stored as facts rather than as tools (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990), is 'welded' to its original occasion of use (Brown, 1997), or as Whitehead suggested, the knowledge has remained 'inert' (Whitehead, 1932).

A number of recent studies have attempted to investigate students' use of knowledge as tools, and the circumstances under which the knowledge remains inert. In a study by Gick and Holyoak (1980) students were presented with the following extract and asked to memorise the information in the passage.

> A general wishes to capture a fortress in the center of a country. There are many roads radiating outwards from the fortress. All have been mined so that while small groups of men can pass over the roads safely, a large force will detonate the mines. A full scale direct attack is therefore impossible. The general's solution is to divide his army into small groups, send each group to the head of a different road, and have the groups converge simultaneously on the fortress.

Students were then given the following problem and asked to solve the problem using the information in the memorised passage.

You are a doctor faced with a patient who has a malignant tumor in his stomach. It is impossible to operate on the patient, but unless the tumor is destroyed the patient will die. There is a kind of ray that may be used to destroy the tumor. If the rays reach the tumor all at once and with sufficiently high intensity, the tumor will be destroyed. At lower intensities, the rays are harmless to healthy tissue, but they will not affect the tumor either. What type of procedure might be used to destroy the tumor with the rays, and at the same time avoid destroying the healthy tissue?

Unless students were specifically told to use the first passage to solve the problem, only 20% used the army analogy to conclude that it was possible to aim the rays from a number of directions to converge on the cancerous tumor. The knowledge from the first story, although memorised, was inert. The Cognition and Technology Group at Vanderbilt (1993c) conclude that: 'People may be able to retrieve and use knowledge when explicitly asked to do so, and yet fail to spontaneously access it or use it. Under these conditions, the knowledge does them little good' (p. 37).

Bereiter (1984) recounts an investigation into reading strategies employed by university students, which found that when asked to learn as much of a difficult article on educational psychology as they could in 10 minutes, almost all students started at the beginning and read through the article until the time was up. When questioned about the techniques employed, they all acknowledged that they knew better strategies and that they had been taught to skim read, check main headings, and read summaries and conclusions. But few had thought to employ these strategies.

The studies described so far have given evidence that formal learning often lies inert in the face of low-level academic and everyday problems. However, other research has shown that a similar pattern can be found in highly technical areas. For example, Morris and Rouse (1985) found that electronic troubleshooting was not performed well in the field despite intensive formal training in electronics and troubleshooting theories. Another study investigated university students' conceptions of logarithms and why they are used (Bransford, Sherwood, et al., 1990). The majority of students had little idea that when logarithms were first invented, they enabled astronomers and mathematicians in the 1600s to easily solve complex calculations with simple addition. Students were asked to nominate what they would take into a test situation which offered prizes for completing large-number multiplication within an hour. Computers, calculators and slide rules were not allowed. Most students did not think to take a book of logarithms. They saw logarithms as relevant to logarithm problems, and as

'difficult ends to be tolerated rather than exciting inventions that allowed a variety of problems to be solved' (Bransford, Sherwood, et al., 1990, p. 117).

Bransford, Vye, Kinzer and Risko (1990) maintain that the failure to access relevant information in a problem-solving context is largely adaptive because access to knowledge needs to be selective. Consciously thinking through everything we know to solve a problem would be inefficient and time consuming. Nevertheless, these studies suggest that much of the formal, decontextualised and abstract knowledge taught in schools and universities is not retrievable in real-life, problem-solving contexts, because this approach ignores the interdependence of situation and cognition.

Decontextualised instruction

When learning and context are separated, knowledge itself is seen by learners as the final product of education rather than a tool to be used dynamically to solve problems. Cole (1990) contends that traditional education overemphasises the acquisition of facts and procedures, a situation that Entwhistle, Entwhistle and Tait (1993) argue is bolstered by the nightly quiz shows on television which 'publicize and reward ... incremental, decontextualized knowledge' (p. 335).

Research by Miller and Gildea (1987) explores the discrepancy between the vocabulary that school children learn, and the vocabulary they are taught. They contend that teachers in schools attempt to teach no more than about 200 words per year, yet school children learn about 5000 words per year. Children learn vocabulary efficiently and effectively at this rate (over 13 words per day for up to 16 years) generally without the help of standard vocabulary teaching strategies, such as dictionary exercises. Miller and Gildea's study gives examples of students' attempts to use vocabulary when they were taught in a typical school manner using decontextualised dictionary definitions and exemplary sentences. Table 2.1 shows the sentence the student wrote and the excerpt of the dictionary definition that led to the meaning of the word in the sentence.

Table 2.1:   Use of vocabulary acquired from dictionary definitions (Miller & Gildea, 1987)

Sentence	Excerpted dictionary meaning
Our family *erodes* a lot.	Eats out, eats away
Mrs. Morrow *stimulated* the soup.	Stir up
Me and my parents *correlate*, because without them I wouldn't be here.	Be related
I was *meticulous* about falling off the cliff.	Very careful
The news is very *tenet*.	True
The *redress* for getting well when you're sick is to stay in bed.	Remedy
I *relegated* my pen pal's letter to her house.	Send away.

This teaching method assumes that each word definition is a discrete, self-contained piece of knowledge, and it ignores the fact that language is developed through 'continued, situated use' (Brown, et al., 1989b, p. 33). Miller and Gildea also maintain that it is ineffective to give an example of the word in a model sentence. For example given the sentence: 'The king's brother tried to usurp the throne' the children concluded 'usurp' was equal to 'take' and wrote sentences such as 'The thief tried to usurp the money from the safe' (Miller & Gildea, 1987, p. 90).

Bereiter (1984) draws a distinction between *teaching about thinking* and *teaching thinking*. He contends that the teaching of declarative knowledge should be seen not as an end in itself but merely the first step in gaining cognitive skills. Such declarative knowledge needs to be followed up 'by a proceduralization stage, in which the knowledge becomes manifested in the actual behaviour of the learners' (p. 76).

Learners in formal educational settings are typically taught to use symbols in problem solving, a process which often results in the connections between the symbols, and the events and objects they represent, being lost (Resnick, 1987b). In contrast, learners in authentic, everyday situations use the physical elements of the situation directly to help solve the problem and rarely lose sight of the quest. The following section looks at some of the research into contextualised learning within everyday, authentic situations.

Contextualised learning in authentic situations

Context is important for cognition not only in determining how a problem will be perceived, but also in providing the supports and the strategies that the learner will use

to solve it (Ceci & Ruiz, 1993b). Scribner (1984) describes research into how dairy workers use mathematics in filling orders and taking inventories. She found that 'preloaders', who were required to fill orders of partial crates of milk were much more adept at using the environment directly to calculate the orders than clerks given the same task. Experienced preloaders used elements of the problem—case size, visual appearance and spaces—to assist in its solution, whereas the clerks used counting operations and numerical solutions. For example, Scribner notes down a clerk's thinking as she filled an order for a case minus 6 quarts: 'I'm going to remove six quarts and put them in an empty case ... oh no that's wrong. It was one case minus six so there's two, four, six, eight, ten, sixteen. So there should be ten in here' (p. 26). In contrast, an experienced preloader describes how he filled an order for half a case: 'I walked over and I visualized it. I knew the case I was looking for had ten out of it, and I only wanted eight so I just added two to it ... I do it visual, a visual thing, you know' (p. 26). Scribner found a complete absence of 'overt counting' by preloaders, but they achieved accurate results by using the elements of the problem directly in finding the solution, rather than using symbols.

Another example of the way physical objects can be used directly in a problem-solving situation can be found in the work of Carraher, Carraher and Schliemann (1985). Their study compared the way Brazilian children solved mathematical problems selling coconuts in the streets and in a school setting. The children's performances on the formal test contrasts strongly with the more accurate results in the real-life situation, as this example of the responses of a 9 year old child illustrates:

Formal test: Child solves the item 40 x 3 and obtains 70. She then explains the procedure 'Lower the zero; 4 and 3 is 7'.

Informal test: Customer: OK, I'll take three coconuts ... How much is that?
Child: (Calculates out loud) 40, 80, 120 (p. 26)

A number of other studies add support to the argument that real-life problem-solving draws more from the context of the problem itself than from the application of formally taught knowledge and symbols. Fishermen were interviewed on the beach, in a study by Schliemann and Nunes (1990), and asked to calculate prices of fish, weights and earnings per kilogram. Regardless of their years of formal schooling, between 70% and 90% of the fishermen could answer the problems correctly using non-school taught processes. Similarly, studies by Saxe investigating mathematical understanding in child candy sellers (Saxe, 1988), Lave researching the mathematics embedded in the work practice of tailors in West Africa (Lave & Wenger, 1991), and shoppers calculating

best buys in supermarkets (Lave, Murtagh, & de la Rocha, 1984; 1988) have found little correspondence between the complex mathematical calculations performed out-of-school and the mathematics people are taught in school.

The findings from these studies suggest that in real-life problem-solving, the physical properties of the problem itself are frequently used to work out the solution, and that these solutions are more accurate and achieved more quickly than through formally taught methods. Resnick (1987b) notes that people in real-life contexts rarely forget what their reasoning or calculation is about because they are working directly with the objects and situations that apply. A disadvantage of situation-specific learning, however, is that if a task changes substantially, the invented methods may fail altogether. Resnick contends that in these cases, people rarely revert to the school taught methods but invent new methods which use the context of the problem in a different way to accommodate the new demands.

While the research into learning in real-life situations has consistently provided evidence of the effectiveness of contextualised strategies in solving problems, the methods used are at times 'inappropriate and primitive' (Saxe, 1988, p. 20). There is no general agreement amongst the researchers that formal instruction should be abandoned in favour of content and context-dependent strategies which are learnt 'on the job' despite the claims of some of the critics of the situated learning approach (e.g., Anderson, Reder, & Simon, 1996; Sandberg & Wielinga, 1991). Rather, the implication from this research is to determine the pedagogical significance of the findings and to promote appropriate and effective classroom techniques and practices to foster contextualised learning.

Situated cognition

There have been several attempts to use the findings of the research into contextualised learning to design a model of instruction. For example, Resnick (1987b) pre-empted later models by proposing that 'bridging apprenticeships' be designed to bridge the gap between the theoretical learning in the formal instruction of the classroom and the real-life application of the knowledge in the work environment.

However, it was Brown, Collins and Duguid (1989b) who developed the theory of *situated cognition* or *situated learning* and produced a proposal for a model of instruction that has implications for classroom practice. Collins (1988) defines situated learning as: 'the notion of learning knowledge and skills in contexts that reflect the way the knowledge will be useful in real life' (p. 2).

The model arose out of observation of successful learning situations by the researchers. They set out to find examples of learning in any context or culture which were effective, and to analyse the key features of such models. One such model was snow skiing, where learning time had diminished from two years to two weeks as a result of instruction (Burton, Brown, & Fischer, 1984). An analysis of common features found in all the successful models was a set of six critical factors: apprenticeship, collaboration, reflection, coaching, multiple practice and articulation (McLellan, 1991).

In proposing their model of situated cognition, Brown et al. (1989b) argue that, contrary to many existing teaching practices which abstract knowledge from context, meaningful learning will only take place if it is embedded in the social and physical context within which it will be used. School work is often quite distinct from authentic activity. Many of the activities undertaken by students are unrelated to the kind performed by practitioners in their everyday work. Authentic activities are defined as 'the ordinary practices of the culture' (p. 34).

In an elaboration of the cognitive apprenticeship model, Collins, Brown and Newman (1989) contend that traditional apprenticeships have three characteristics that are cognitively important and should be incorporated into a model of situated learning:

1.   Learners have continual access to models of expertise-in-use against which to refine their understanding of complex skills.

2.   Apprentices often have several masters and have access to a variety of models of expertise leading to an understanding that there may be different ways to carry out a task, and that no one individual embodies all knowledge and expertise.

3.   Learners have the opportunity to observe other learners with varying degrees of skill. (p. 456)

Collins, Brown and others (Collins, et al., 1989; Collins, Brown, & Holum, 1991) propose a framework for designing learning environments which incorporates four dimensions: content, methods, sequence and sociology. Table 2.2 shows each of these dimensions together with its characteristics.

Table 2.2: Characteristics of ideal learning environments (adapted from Collins, Brown and Newman, 1989; and Collins, Brown and Holum, 1991)

Dimension	Type	Description
Content Types of knowledge required for expertise	Domain Knowledge	Subject-matter specific concepts, facts and procedures
	Heuristic strategies	Generally applicable techniques for accomplishing tasks
	Control strategies	General approaches for directing one's solution process
	Learning strategies	Knowledge about how to learn new concepts, facts and procedures
Methods Ways to promote the development of expertise	Modelling	Teacher performs a task so that students can observe
	Coaching	Teacher observes and facilitates while students perform a task
	Scaffolding	Teacher provides supports to help the student perform a task
	Articulation	Teacher encourages students to verbalise their knowledge and thinking
	Reflection	Teacher enables students to compare their performance with others
	Exploration	Teacher invites students to pose and solve their own problems
Sequence Keys to ordering learning activities	Global before local skills	Focus on conceptualising the whole task before executing the parts
	Increasing complexity	Meaningful tasks gradually increasing in difficulty
	Increasing diversity	Practice in a variety of situations to emphasise broad application
Sociology Social characteristics of learning environments	Situated learning	Students learn in the context of working on realistic tasks
	Culture of expert practice	Communication about different ways to accomplish meaningful tasks
	Intrinsic motivation	Students set personal goals to seek skills and solutions
	Exploiting cooperation	Students work together to accomplish their goals

Collins (1988) lists four benefits of situated learning as a model of instruction:

1. *Students learn conditions for applying knowledge:* If students have learnt knowledge in a representative context, such as arithmetic in the context of grocery shopping or banking, then they will be better prepared to apply the knowledge in novel situations by analogy to the original learning context.

2. *Situations foster invention:* Real problems and situations are more likely to require students to invent responses, solutions and sub-tasks in applying their knowledge. They are required to use their knowledge flexibly, as a tool, in novel situations rather than as a fixed body of facts or rules.

3. *Students see the implications of the knowledge:* In school learning, it is often not obvious to students how the knowledge they are learning will be applied in real life. When learning is embedded within context, they can see from the beginning how the knowledge is used in different situations and its significance.

4. *Context structures knowledge appropriate to its uses:* Students often invoke 'suboptimal schemes' for remembering information to pass tests and to cope with the day-to-day demands of school learning. For example, arithmetic students might conclude that any word problems including the word 'left' (How many did she have left?) are subtraction problems. Or they might use rhymes or mnemonics to memorise decontextualised facts (Thirty days has September, April June and November). Such knowledge is less likely to be stored in a form that is useable when applied to novel situations (pp. 2-3).

A critical aspect of the situated learning model is the notion of the apprentice observing the 'community of practice'. Lave and Wenger (1991) propose that participation in a culture of practice can, in the first instance, be observation from the boundary or 'legitimate peripheral participation'. As learning and involvement in the culture increase, the participant moves from the role of observer to fully functioning agent. Legitimate peripheral participation enables the learner to progressively piece together the culture of the group and what it means to be a member. 'To be able to participate in a legitimately peripheral way entails that newcomers have broad access to arenas of mature practice' (Lave & Wenger, 1991, p. 110):

> From a broadly peripheral perspective, apprentices gradually assemble a general idea of what constitutes the practice of the community ... who is involved; what they do; what everyday life is like; how masters talk, walk, work, and generally conduct their lives ... how, when, and about what old-timers collaborate, collude, collide, and what they enjoy, dislike, respect, and admire. (Lave & Wenger, 1991, p. 95)

Lave and Wenger (1991) propose that one of the main functions of legitimate peripheral participation is to enable the learning of the language and stories of a community of practice. It order to participate fully it is important not only to learn from the language, but also to learn how to speak both within and about the practice.

While the publication of the model of situated learning has met with much interest and acclaim, for example Farnham-Diggory (1992) believes that the model 'will be recognised as a genuinely new educational model ... I believe it is where contemporary scientific principles lead us' (p. 558), it has also been widely challenged, debated and questioned. The arguments fall into five broad, but interrelated areas: whether transfer can be enhanced, whether higher-order thinking can be promoted, the value of the apprenticeship metaphor, whether the model can be used successfully in the classroom, and whether the model can be used in computer-based learning environments. Each of these areas of contention will be discussed in the following sections.

Transfer

One of the principal effects claimed for situated learning is that it facilitates transfer of learning to new situations (Young, 1993; Cognition and Technology Group at Vanderbilt, 1993a). Park and Hannafin (1993) cite the improvement of transfer as the distinguishing feature of situated learning as a theory in their analysis of new learning theories and the implication of each for the design of interactive multimedia.

The literature is divided on the evidence for transfer. Several writers and researchers, (e.g., Ceci & Ruiz, 1993a; Detterman, 1993) indicate that, regardless of which instructional strategy is employed, there is little evidence of the effectiveness of transfer from one situation to another no matter how similar the problems. Sternberg and Frensch (1993) contend that the failure of transfer from one setting to another is common: 'Transfer of training often appears to be the exception rather than the rule, whether in school or outside of it' (p. 25). Detterman (1993) summarises a number of transfer studies which have examined near and far transfer of deep and surface structures, and concludes:

> The amazing thing about all these studies is not that they don't produce transfer. The surprise is the extent of similarity it is possible to have between two problems without subjects realizing that the two situations are identical and require the same solution. (p. 13)

Sandberg and Wielinga (1992) argue that a situated learning approach to complex problems is no solution: 'It does not reduce the inherent complexity of the problem. And it may be feared that it only conceals this complexity, by offering to "solve" a problem in a situated manner ... and thus failing to abstract from the particular context' (p.136). However, Prawat (1992) argues that a dramatic change is needed in our current view of transfer: 'The central assumption that underlies this view—the notion that one typically learns something in one context and applies it in another—... is mischievous because it emphasizes the lifting of knowledge or skill out of one context before plugging it into another' (p. 380).

In recent debate, Anderson, Reder and Simon (1996) have been critical of the 'claim of situated cognition—of the failure of knowledge to transfer' (p. 6). They argue that there is an abundance of evidence to show that learning *can* transfer. In so doing they attribute a blanket judgement on transfer to the proponents of situated learning, mistakenly contending they maintain that *no* learning can transfer. In fact, this is one of the main arguments for change, that in moving from a decontextualised, abstract approach to a situated, authentic context, transfer will be enhanced.

Interestingly, one of the studies Anderson et al. (1996) cite as evidence of effective transfer, Brown and Campione (1994), uses precisely the kinds of conditions advocated by the proponents of situated learning to promote transfer. Brown and Campione's 1994 study, is described as follows in their own words:

> Wherever possible, we situate academic activities such that the goals of the enterprise are apparent to the participants ... There is often a dramatic lack of continuity between school activities and the cultures of both childhood and legitimate adult occupations ... We attempt to forge a link between school activity and outside activities. (p. 269)

Brown and Campione are discussing here the methods they used to minimise the lack of transfer caused by the decontextualised nature of traditional classroom learning. They are using similar methods to those advocated by the proponents of situated learning , (such as authentic context, authentic activity, collaboration, articulation and scaffolding) and by Anderson et al's (1996) admission, they have succeeded. Another study cited by Anderson et al. as evidence of transfer is Schoenfeld's (1985) study of mathematical problem solving. It too affects transfer by implementing a program which treated students as real mathematicians, again operationalising elements of the situated learning model.

Elshout (1990) cited in (Sandberg & Wielinga, 1992) argues that the abstract representation of knowledge is not the problem. He contends that 'at the root of failure to transfer lies failure to comprehend complex information' (p. 136). However, others contend that in any discussion of the issue, transfer cannot be distinguished from learning (e.g., Butterfield, Slocum, & Nelson, 1993), the assumption being that if something is learnt well it will be applied. The Cognition and Technology Group at Vanderbilt (1993a) describe five types of transfer that they are trying to promote: (1) transfer to new analogous problems; (2) transfer to partially analogous problems; (3) transfer to 'What If' perturbations of the original problem; (4) transfer outside the classroom context; and (5) transfer as efficient learning (pp.60-62). These last two points reflect the position that transfer of knowledge is facilitated if it is well learned to begin with, a process that Prawat (1992) asserts is best done 'by building connections—both of the knowledge-knowledge and of the knowledge-context variety. The richness of connections between elements of knowledge ... directly affects the accessibility of any aspect of knowledge in a novel situation' (p. 381). This view is supported in part by Orey and Nelson (1994) who contend that knowledge acquired in formal, non-situated school settings will transfer if it is 'understood well enough' (p. 623).

Resnick and Resnick (1992), however, contend that the linking and interpretation of new knowledge of the kind proposed in a situated learning environment is vitally important if it is to be used dynamically in new situations:

> Recent cognitive research teaches us to be highly respectful of knowledge as a requirement for good thinking. Study after study shows that people who know more about a topic reason more profoundly about that topic than people who know little about it. But the knowledge required for good thinking can only be required through processes of thinking. For concepts and organizing knowledge to be mastered, they must be used generatively—that is, they have to be called upon over and over again as ways to link, interpret, and explain new information. Education requires an intimate linking of thinking processes with important knowledge content. (p. 41)

The research proposed here will investigate the extent to which those 'rich connections' have been made by students working in a situated learning environment, and whether knowledge learned transfers to real world practice, as described in points 4 and 5 of Cognition and Technology Group at Vanderbilt (1993a) types of transfer.

Higher-order learning

Students entering university in the late twentieth century and the early twenty-first century will be faced, at their graduation, with a world where information has doubled since they started their degrees (Dalton, 1994). A fast-changing, information-hungry society means that an education based on existing knowledge in a field will be redundant before it has a chance to be utilised (diSessa, 1988; Latchem, 1993). The principal task of schools and universities can no longer be the simple transmission of a body of knowledge packaged into discrete subject areas, but the much more challenging task of producing 'adaptive learners' who can respond effectively to changing demands and unpredictable circumstances (Resnick, 1987b, p. 18). For students, the mere accumulation of facts and concepts is less critical, and will allow them to contribute less to society, than the promotion of higher-order thinking and problem-solving (Vockell & van Deusen, 1989).

The proponents of situated learning argue that the type of learning environment they propose has a major strength which decontextualised learning lacks: a situated learning environment promotes higher-order learning. Collins, Brown and Newman (1989) suggest that higher-order learning—'cognitive and metacognitive strategies and processes'—can 'best be taught' through methods that employ a situated learning approach (p. 455). While higher-order learning (or higher-order thinking as it is described in much of the literature) might most simply be described as 'all intellectual tasks that call for more than information retrieval' (Baker, 1990), it is recognised as being extremely difficult to define precisely. Cuban (1984) has described the task as a 'conceptual swamp' (p. 676).

The use of the term *higher-order thinking* itself has met with some discussion. Educationalists and psychologists prefer the term over the rival *critical thinking* because this latter term has strong association with philosophy, literature and critiquing (Lewis & Smith, 1993). However, Resnick (1987a) points out that the fundamental problem with the term *higher-order thinking* is that it is misleading because it implies a hierarchy of skills and a set of 'lower order' thinking skills that must precede the higher-order skills. According to Resnick, higher-order thinking is 'an intimate part of even elementary levels of ... learning—when learning is proceeding well' (p. 8). Others have pointed out that higher-order thinking is relative—a task that calls for higher-order thinking by one person may only require lower order thinking by another (Newmann, 1990).

This view is counter to earlier behavioural theorists such as Bloom (1956) and to some extent, Gagné (1985). The higher levels of Bloom's taxonomy (*analysis, synthesis* and *evaluation,* and sometimes *comprehension* and *application*) are often given as a definition of higher-order thinking (Ennis, 1993), but the hierarchical nature of the taxonomy means that each level is assumed to include the previous level (Farnham-Diggory, 1992). Similarly, Gagné's analysis of cognitive processes and intellectual skills is, according to Baker (1990) 'frequently construed to have a hierarchical character' (p. 7).

There have been many other attempts to formulate definitions of higher-order thinking. Vockell and van Deusen (1989) classify higher-order thinking skills into four major categories: metacognitive skills, critical and creative thinking, thinking processes and core thinking skills. Lewis and Smith (1993) offer the following definition: 'Higher order thinking occurs when a person takes new information and information stored in memory and interrelates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations' (p. 136). According to this definition, purposes of higher-order thinking would include: 'deciding what to believe; deciding what to do, creating a new idea, a new object, or an artistic expression; making a prediction; and solving a nonroutine problem' (p. 136). Ennis (1993) defines higher-order or critical thinking as 'reasonable, reflective thinking focused on deciding what to do or believe' (p. 180). Such thinking is characterised by actions such as: judging the credibility of sources, identifying conclusions, developing and defending a position on an issue, asking appropriate clarifying questions, and drawing conclusions when warranted but with caution (Ennis, 1993).

Newmann (1990) describes 17 'indicators of classroom thoughtfulness', an instrument used in his research into higher-order thinking skills in social studies classrooms. The indicators were divided into three categories: general (e.g., there was a sustained examination of a few topics rather than superficial coverage of many), teacher behaviour (e.g., the teacher was a model of thoughtfulness) and student behaviour (offering explanations for their conclusions; generating original and unconventional ideas, explanations, hypotheses or solutions to problems; assuming the role of questioner and critic; making contributions which are articulate relevant and connected to prior discussion). Other classification schemes from the literature on interactive multimedia also consider higher-order learning, such as Duchastel's four cognitive processes of hypermedia interaction: browsing, searching, integrating and angling (Duchastel, 1990, p. 227).

There is an abundance of literature on the nature of thinking, problem solving and reasoning. As Newmann (1990) points out, each approach has its own persuasive

rationale. He contends that it is not productive to try to choose the best, but more sensible 'to search for a common conception that embraces diverse emphases but which attracts professional consensus' (p. 42).

The definition of higher-order thinking offered by Resnick (1987a) provides nine distinguishing features which, because of their general nature, accommodate the more specifically defined observable criteria offered by many other classification schemes. Resnick's characteristics of higher-order thinking are:

1. Higher order thinking is *nonalgorithmic*. That is the path of action is not fully specified in advance.

2. Higher order thinking tends to be *complex*. The total path is not 'visible' from any single vantage point.

3. Higher order thinking often yields *multiple solutions*, each with costs and benefits, rather than unique solutions.

4. Higher order thinking involves *nuanced judgement* and interpretation.

5. Higher order thinking involves the application of *multiple criteria*, which sometimes conflict with one another.

6. Higher order thinking often involves *uncertainty*. Not everything that bears on the task at hand is known.

7. Higher order thinking involves *self-regulation* of the thinking process. It is not recognised in an individual when someone else 'calls the plays' at every step.

8. Higher order thinking involves *imposing meaning*, finding structure in apparent disorder.

9. Higher order thinking is *effortful*. There is considerable mental work involved in the kinds of elaborations and judgements required. (p. 3)

These characteristics are not discrete, nor necessary in their entirety for higher learning to occur. As Newmann (1990) points out, 'all higher order challenges … need not manifest all of Resnick's criteria' (p. 45).

To date, there appears to have been scant research into whether higher-order thinking is enhanced and promoted by learning environments based on a situated learning framework. However, some studies have been conducted using computer-based learning environments, which investigate students' use of higher-order thinking as they use multimedia packages. For example, Maor investigated the extent to which computer-based learning environments facilitated students use of higher-level thinking (Maor & Taylor, 1995). In the study, two classes of students conducted scientific inquiry into the natural environment of birds of Antarctica. The study found that the teacher's epistemology influenced the occurrence of higher-level thinking skills, and that these skills were much more evident in the classroom where the teacher implemented a 'constructivist-oriented' as opposed to 'transmissionist-oriented' pedagogy.

It is interesting to compare these results to other studies which have found little evidence of higher-order thinking. For example, Frampton (1994) analysed cognitions of tertiary students using a interactive multimedia package on the wars in which Australia had been involved in the twentieth century. The study found: 'We were unable to locate other than occasional possible instances [of higher-order cognition] either in relation to specific segments of recorded events or in a more holistic overview of a complete session' (p. 89). Describing the same study, Alexander and Frampton (1994) disclose the task set the students as they used the interactive multimedia program. It was: 'Find out all you can about Australia at the beginning and during World War Two'. Clearly, the dissimilarity between this straightforward fact-finding task and the authentic, complex tasks advocated by the proponents of situated learning negates the drawing of any relevant conclusions about higher-order thinking from such a study. Other studies which have found little evidence of higher-order thinking, such as Oliver and McLoughlin (1997), have focused on telecommunication learning environments which employed an instructional design not compatible with situated learning.

While the proponents of situated learning continue to claim that higher-order learning is a consequence of learning within a situated learning environment, very little research has been done to evaluate the impact of situated learning elements on students' thinking, particularly with regard to the use of interactive multimedia programs.

A third area of contention within the literature on situated learning is the value of the apprenticeship model, which is discussed in the next section.

The apprenticeship debate

Brown, Collins and Duguid (1989b) model their theory of situated cognition in part upon the traditional craft apprenticeship which 'enables apprentices to acquire and develop the tools and skills of their craft through authentic work and membership in their trade ... So the term *apprenticeship* helps to emphasize the centrality of activity in learning and knowledge and highlights the inherently context-dependent, situated, and enculturating nature of learning' (p. 39). In supporting their argument of the effectiveness of apprenticeships, Brown et al. (1989b) use examples such as apprentice tailors whose main task is to iron and press finished garments. The work is often menial, and yet totally meaningful and authentic, leading to a tacit understanding of the process of garment production.

Wineburg (1989) criticises the depiction by Brown et al. (1989b) of the apprenticeship as the noble and worthwhile exemplar of quality learning, while the school is presented as a 'wasteland' of didactic education (p. 9). He draws a parallel with the 'Noble Savage' argument in Western social criticism, where modern institutions and behaviours are often unjustly compared to uncorrupted, authentic cultures. He is critical of the generalised manner in which all apprenticeships are glorified: 'No doubt some apprentices find their apprenticeship absolutely authentic, but I can imagine others who find it absolutely tedious, inefficient, repressive, servile, tradition-bound, and in some cases, downright mean' (p. 9).

Lave and Wenger (1991) acknowledge this argument by noting that the quality and consistency of apprenticeships vary enormously. They argue that apprenticeships do not inevitably result in learning in practice. Included in a series of case studies, they give the example of apprentice butchers who were used in ways more consistent with profit-making than incorporating them into the practice of meat-cutting. For example, a new apprentice might be assigned to the automatic wrapping machine and stay on that single task for years until a new apprentice comes along. Lave and Wenger argue that the apprenticeship itself is not the issue. There can be apprenticeships where 'masters prevent learning by acting in effect as pedagogical authoritarians' (p. 76). The critical issue is the legitimate peripheral participation the apprenticeship allows.

The Cognition and Technology Group at Vanderbilt (1990a) admit that the learning experiences they create, essentially to teach mathematics such as the Jasper series (described in more detail in the following section), are not the type of experiences one might expect to learn from an apprenticeship to a real mathematician. They liken it instead to an apprenticeship to a well-informed parent who assists the child to learn

skills and knowledge that will be useful in everyday life. Their view of the learning environments that they produce is that they have 'the potential to create learning experiences that are *more effective* than many that occur in traditional apprenticeship training' (p. 8).

These criticisms, however, tend to target the traditional apprenticeship model and do not reflect the progress and elaboration of the metaphor from *traditional* apprenticeship to *cognitive* apprenticeship as developed by both Brown, Collins and Duguid (1989) and Collins, Brown and Newman (1989). They argue that there are two essential features of cognitive apprenticeships that are not present in traditional apprenticeships: firstly, tasks and problems are selected to illustrate the power of certain techniques, and they are sequenced 'to reflect the changing demands of learning' (Collins, et al., 1989, p. 459), and secondly, the learning environment is extended to provide for a variety of diverse situations, not the single, dedicated setting of the traditional apprenticeship. And importantly, they also point out that the relative success of the apprenticeship system is not adequately explained in current cognitive theory, and that some research into isolating those critical elements may mean that they can be replicated in the classroom 'through apprentice-like teaching methods' (Brown, Collins, & Duguid, 1989a, p. 12).

Many of the criticisms of attempts to use situated learning as a model of instruction have been based on how closely the learning environment resembles, not a cognitive apprenticeship, but a traditional apprenticeship. Tripp (1993) has a particularly narrow set of criteria to define situated learning, which equates very much with a standard apprenticeship. This approach denies the possibility envisaged by Brown, Collins and Duguid in their original 1989 article, that a theory of situated learning could be developed into a model of instruction as research isolates those 'critical elements' that make apprenticeships successful (Brown, et al., 1989a).

The application of the model of situated learning in the classroom is the fourth area of dispute which is widely contested in the literature. This is discussed in the next section.

Can situated learning be applied in the classroom?

In a response to the original Brown, Collins and Duguid article in 1989, Wineburg (1989) argued that the abstract representation of knowledge was at least as effective as the situated learning approach and much more readily implemented in the classroom:

> The theory of learning put forth by the authors has generated great excitement ... But to survive in the marketplace of ideas, a theory has to be situated in a *theory of schooling*. Otherwise, it may leave its mark on archival journals but leave the world of classrooms virtually untouched. (Wineburg, 1989, p. 9)

However, the principal theorists of situated learning have consistently argued that their model, when further researched and developed, would be a model for teaching with practical classroom applications (Brown, et al., 1989b; Brown, et al., 1989a; Collins, et al., 1989; Collins, 1988). Brown and Duguid (1993) address the issue of the operationalisation of situated cognition into classroom practice by suggesting four 'oppositional terms' which at one extreme underpin, and at the other undermine, the successful use of the approach.

1. *Instruction vs. Learning*: Learning is not necessarily an outcome of teaching, and a situated approach harnesses the peripheral and 'stolen' knowledge that abound within an authentic context.

2. *Explicit vs. Implicit*: It is very difficult to make explicit much of the implicit knowledge that is inherent to a situation, and yet this is what conventional instruction often tries to achieve. A situated approach acknowledges the different roles of implicit and explicit instruction, and the importance of allowing learners access to implicit knowledge within the practice.

3. *Individual vs. Social*: In order to build connections between learners and the authentic practice, it is important to maintain the links with the practice in which the particular activity makes sense. This is best achieved in a social context with all the richness and knowledge that make up the practice. The individual is not capable of learning in a setting where the social context is missing, regardless of the intensity of the instruction.

4. *Systems narrowly construed vs. Systems broadly construed*: Educational technologies tend to narrow and isolate concepts, skills and ideas to be learnt rather than broadening them to embrace the community of practice. (Brown & Duguid, 1993)

These attempts to provide guidelines on the application of situated learning in the classroom, have also been supported by thinking and research within an instructional

design framework. While accepting the basic tenets of situated learning, and attempting to maximise its applicability in the classroom, Young (1993) describes four essential tasks in instructional design for situated learning:

1. Selection of the situation,

2. Providing 'scaffolding'

3. Providing supports that enable teachers to track progress, assess products, access distributed sources of knowledge and interact knowledgeably and collaboratively with students,

4. Define the role and nature of assessment, and what it means to assess situated learning (p. 45).

Winn (1993) suggests that situated learning can be made more efficient by applying instructional design principles. Instructional design can be used to design worthwhile ways for students to serve their cognitive apprenticeships, to design experiences and activities that bring authentic practices into the classroom, and to plan experiences for students that are situated in the real world.

The literature reveals a number of case studies, and some research, which supports the contention that the situated learning approach can be used successfully as a model of instruction. For example, Lampert (1986) describes a type of mathematical exploration she used with fourth year students learning multiplication. She utilised students' own intuitive knowledge and everyday knowledge as a starting point for explorations which resulted in better understanding and procedural knowledge of mathematics than teaching them the standard algorithm. Lampert began with a simple multiplication problem and encouraged students to think about a story that matched the question. Her description of the process shows that she used a combination of coaching, supporting and articulating to explore the problem, and to lead students to the point where the standard algorithm had meaning and purpose in their own experience.

Griffin (1995) conducted a study to investigate the advantages that situated cognition offers over traditional instructional methods for school learning. In an experiment comparing the situated cognition approach to map skill instruction with a traditional classroom approach, Griffin concluded that situated cognition improves performance on traditional school tasks. The situated cognition group performed significantly better on the performance test in the field. However, there was no significant differences between the groups on a written assessment test or on a performance assessment of the transfer of map skills. Griffin found that situated cognition offers some motivational advantages, that students enjoy this type of instruction and appear to be more

motivated when engaged in complex, authentic activity (p. 84). This view is supported by Gabrys, Weiner and Lesgold (1993) who point out that the internal motivation of the learner is critical for transfer of learning to new situations and that the authenticity of situated learning provides that motivation.

Bransford, Sherwood, Hasselbring, Kinzer, and Williams (1990) describe a model of instruction called 'anchored instruction' which teaches specific content knowledge in the context of problem solving, and which places considerable emphasis on 'creating an anchor or focus that generates interest and enables students to identify and define problems and to pay attention to their own perception and comprehension of these problems' (p. 123). Several research projects, developed by the Cognition and Technology Group at Vanderbilt, incorporate anchored instruction, such as the *Jasper* series, *Raiders of the Lost Ark, The Third Man* and *Young Sherlock Holmes* (Bransford, Sherwood, et al., 1990). Bransford, Vye, Kinzer and Risko (1990) argue that this approach promotes transfer of knowledge by making it more accessible, and that students are able to distinguish between 'knowing X' and 'thinking to use X' (p. 391).

In designing their programs, the Cognition and Technology Group at Vanderbilt (1993a) propose that students begin with an information-rich resource which provides an effective starting point, not a final end point, for instruction. They also see the process as a way to 'equalize the preparation of the students' (p. 57), which is reminiscent of Resnick's 'bridging apprenticeships' (1987b). The Jasper series is a good example of the kind of learning environment developed by the Cognition and Technology Group at Vanderbilt. It is a series of adventures organised into pairs (presenting similar types of problems) where students watch a video of about 15 minutes, which tells a story and sets the scene for the problem. The video ends with the problem being posed. For example: 'What's the fastest way to rescue the eagle, and how long will that take?' In order to solve the problem, students need to generate sub-problems that must be considered before the more complex task can be solved. They use the videodisc to access information from the original problem-setting scene, which is embedded with useful data, and also to replay segments from a number of different perspectives. The authors point out that while the problem looks 'deceptively simple', there are a number of different solutions which can be found in the exploration of flying the eagle to safety, such as payload, range and landing constraints (Cognition and Technology Group at Vanderbilt, 1993b, p. 13). In the Young Sherlock program (Cognition and Technology Group at Vanderbilt, 1990a; Bransford, Vye, et al., 1990) students use the feature-length film *Young Sherlock Holmes* as an anchor for investigating story writing, and the history of the Victorian era. They investigate historical aspects such as

authenticity and inventions (Should Watson be riding in a carriage? Wasn't the car invented then?); scientific concepts such as the climate, weather and geography (Does it snow in December?); and literary elements such as grammar, plot and character development. Students use the video for a full semester to examine the film in detail often from multiple perspectives.

The Cognition and Technology Group at Vanderbilt (1990a) see anchored instruction as a *practical application* of situated cognition in formal educational settings. They acknowledge the logistical difficulties of placing learners into context-rich authentic environments within a formal schooling system (Palincsar, 1989; Wineburg, 1989), but argue that anchored instruction is a feasible way to provide context and is more manageable than organising community-based projects (1993a).

Several authors have criticised attempts to interpret the theory of situated learning into a model of classroom instruction, on the grounds that students are not exposed to real-life situations. Tripp (1993) contends that the Jasper videos are not situated cognition because they are not based on real-life situations but on situations that have 'a richness that resembles reality' (p. 75). In situated learning, one is exposed to a master who performs the skills within an authentic context, and students can acquire these skills by 'stealing moves' (in the terminology of Brown and Duguid). However, many writers in the field believe, like Chiou (1992) that it is 'uneconomical, unnecessary and also impossible' for students to be physically situated in real-world environments (p. 8).

Moore et al. (1994) refute the view presented by Tripp (1993) that situated learning can only occur in non-school settings. They suggest that research into situativity and the way people learn in non-school activities will provide useful knowledge on how those strategies can be used in a school learning environment. They give as an example, the kind of student who can perform complex tasks and reasoning in non-school situations but who performs poorly on school-related tasks. The implications of situated learning research is to provide guidelines on the instructional design of materials to incorporate the learning supports that are intrinsic to real-world problem solving.

Moore et al. (1994) also question Tripp's (1993) suggestion that learning best takes place by observation of a master at work rather than by solving presented problems. They emphasise that active involvement rather than passive observation is crucial, and note that in using their video *The Golden Statuette,* students observing an expert performing various actions had little idea about what she was doing and why. Only the problem-solving activities, where students hypothesised and tested while viewing

the video several times, helped the students to acquire the necessary knowledge to understand what the expert was doing.

For those who question the appropriateness of the situated learning framework in conventional classrooms, the application of the model to computer-based learning is a further step removed from the traditional apprenticeship role. This aspect of the debate is discussed in the next section.

Can situated learning be computer-based?

Many of the criticisms that have been levelled at the application of the situated learning model in the classroom have also been directed at computer-based materials and interactive multimedia that purport to use a situated learning framework in their design. For example, Hummel (1993) describes a distance education course on *Soil and Environment* which is based on ideas from situated learning theory. At the same time, Hummel rejects the idea that the program is true situated learning by virtue of the fact that it is computer-based. 'Instructional designers who apply situated learning theory by implementation in electronic media should realize that they take an important step away from this theory ... courseware becomes the learning environment and not the authentic situation' (p. 15). Similarly, Tripp (1993) contends that such computer-based simulations of the world, such as those readily provided by virtual reality and interactive multimedia, are not sufficient and reiterates that 'true expertise is learned by being exposed to experts' (p. 75).

There is increasing agreement, nonetheless, that computer-based representations and 'microworlds' do provide a powerful and acceptable vehicle for the critical characteristics of the traditional apprenticeship to be located in the classroom environment. For example, Harley (1993) supports the potential of educational technology to bring situated learning within the reach of the student in the classroom, particularly through developments in virtual reality and hypermedia. Reeves (1993a) considers that one of the major benefits of a well designed interactive multimedia environment is its ability to include 'opportunities for simulated apprenticeships as well as a wealth of learning support activities' (p. 107). Similarly, Collins, Brown and Newman (1989) see a role for computer-based technologies in the fostering of apprenticeship-style learning in schools. They argue that computer systems will not take total responsibility for the learning that occurs, but that they might 'augment the master teacher' (p. 491).

Ebel expresses the view that education 'is in need of creative invention to make it work better' (Farley, 1982, p. 18). Several projects and interactive multimedia programs are described below which include substantial elements of a situated learning framework, and appear to offer the kind of creative invention envisaged by Ebel. Collins (1988) gives examples of two exemplary situated learning projects based on computer and communications technology. One entitled *Geography search* is a simulated computer-based microworld where students sail ships from England to America in the time of Columbus. The aim is to look for treasure in North and South America. Students have to negotiate other ships and navigate using sextants and compasses in the way sailors of the time would have. They also have to take account of levels of supplies of food and fresh water to ensure they have enough for the journey. The second program is a constitutional convention where students use email communication to conduct a convention on a draft constitution. Groups from different schools represent the different states of America in 1787 and are required to prepare for the debate by drawing up a list of concerns of their states. During the convention the students negotiate a draft constitution to correct the existing difficulties encountered by the states (Collins, 1988, p. 3).

Computer-based simulations have recently been designed to supplement the Jasper series by the Cognition and Technology Group at Vanderbilt (1993a), a series they offer as an example of situated learning. One program prompts students to make qualitative and quantitative decisions about different ways to rescue the eagle featured in the episode described earlier. Students can receive feedback on the feasibility of their chosen plan, and have the chance to reflect on the plan and try again. The authors believe that there are two real advantages in using computer-based programs with the Jasper series: firstly, students are highly motivated, and engage in 'what-if thinking'; and secondly, the simulations encourage students to think systematically and plan their responses well.

Many of the researchers and teachers exploring the model of situated learning have accepted that the computer has provided an alternative to the real-life setting, and that such technology can be used without sacrificing the authentic context which is such a critical element of the model.

McLellan (1994) sums up these approaches by pointing out that while knowledge must be learned in context according to the situated learning model, that context can be:

1. The actual work setting

2. A highly realistic or 'virtual' surrogate of the actual work environment

3. An anchoring context such as a video or multimedia program (p. 8).

Technology and computer-based systems per se do not have the ability to create a situated learning environment for a student in a classroom. Those critical elements that define the situated learning model as it has evolved, need to be deliberately planned and incorporated into the design. However, interactive multimedia, with its capacity to incorporate a variety of media including sound, animations and video excerpts, has an enormous potential to provide exemplary and effective situated learning opportunities within classrooms:

> The more educational technology is constrained to 'essentials' and 'individuals', the more it resembles a nugatory 'delivery system'... A preferable goal ... is to design technology that provides an underconstrained 'window' onto practice, allowing students to look through as much of actual practice as it can reveal, to see increasingly greater depths, and to collaborate in exploration. (Brown & Duguid, 1993, p.14)

Critical characteristics of situated learning for an instructional design model

Brown, Collins and Duguid (1989b), in their original article, presented a *nascent* theory of situated learning. From the start they suggested that their model was an attempt to begin the process of developing a theoretical perspective for successful learning that cognitive science had, to date, not been able to explain:

> One of our goals is to try to understand what underlies successful learning and to try to produce better methods of teaching. Apprenticeship and related learning methods seem particularly successful, but standard cognitive theory is inadequate for explaining the success. (Brown, et al., 1989a, p. 12)

Lave and Wenger (1991) cautioned that the conception of situated learning was substantially 'more encompassing in intent than conventional notions of "learning in situ" or "learning by doing" for which it was used as a rough equivalent' (p. 31). The challenge put to researchers was to identify the critical aspects of situated learning to enable it to translate into teaching methods which could be applied in the classroom. Although McLellan (1994) summarises the key components of the situated learning model as: apprenticeship, collaboration, reflection, coaching, multiple practice, and articulation of learning skills (p. 7), the contributions of various theorists and

researchers, including the original authors of the model, have expanded and refined the notion to a much more comprehensive and far-reaching framework for classroom application.

A critical reading of the principal theorists (and critics) of situated learning, as described in the literature review above, reveals a number of important characteristics which have added to the evolving theory of situated learning, and an attempt has been made to isolate those characteristics. Many of these authors believe that useable knowledge is best gained in learning environments which feature the following characteristics. Situated learning environments:

1. Provide *authentic context* that reflect the way the knowledge will be used in real life (Brown, et al., 1989b; Collins, 1988; Young, 1993; Winn, 1993; Resnick, 1987b; Moore, et al., 1994; Tripp, 1993; Palincsar, 1989; Harley, 1993; Gabrys, et al., 1993):

    - which preserves the full context of the situation without fragmentation and decomposition (Brown & Duguid, 1993; Resnick, 1987b; Harley, 1993)

    - which *allows for the natural complexity of the real world* (Brown & Duguid, 1993; Collins, et al., 1989; Cognition and Technology Group at Vanderbilt, 1990a; Gabrys, et al., 1993; Cognition and Technology Group at Vanderbilt, 1993c; Cognition and Technology Group at Vanderbilt, 1993a)

2. Provide *authentic activities* (Brown, et al., 1989b; Young, 1993; Cognition and Technology Group at Vanderbilt, 1990a; Winn, 1993; Resnick, 1987b; Tripp, 1993; Harley, 1993; Griffin, 1995):

    - which are *ill-defined* (Brown, et al., 1989b; Cognition and Technology Group at Vanderbilt, 1990a; Winn, 1993)

    - which promote *exploration* where students find as well as solve the problems (Collins, et al., 1989; Collins, 1988; Cognition and Technology Group at Vanderbilt, 1990a; Bransford, Sherwood, et al., 1990; Bransford, Vye, et al., 1990)

    - which *provide the opportunity to detect relevant and irrelevant material* (Young, 1993; Cognition and Technology Group at Vanderbilt, 1990a)

    - which allow *sustained thinking by exploring topics in depth* (Cognition and Technology Group at Vanderbilt, 1993c; Bransford, Sherwood, et al., 1990; Bransford, Vye, et al., 1990)

    - where tasks can be *integrated across subject areas* (Bransford, Vye, et al., 1990; Bransford, Sherwood, et al., 1990)

3. Provide access to *expert performances* and the modelling of processes (Collins, et al., 1989; Collins, 1988; Tripp, 1993)

   • which provides opportunities for *observation* of the task before the student attempts it (Collins, et al., 1989; Resnick, 1987b)

   • which allow for *narratives and stories* to be shared (Brown, et al., 1989b; Brown & Duguid, 1993; Lave & Wenger, 1991)

   • which employ the *social periphery* (legitimate peripheral participation) (Lave & Wenger, 1991; Brown & Duguid, 1993; Tripp, 1993)

4. Provide *multiple roles and perspectives* (Brown, et al., 1989b; Collins, et al., 1989; Cognition and Technology Group at Vanderbilt, 1990a; Cognition and Technology Group at Vanderbilt, 1993a; Cognition and Technology Group at Vanderbilt, 1993b; Cognition and Technology Group at Vanderbilt, 1993c; Lave & Wenger, 1991; Bransford, Sherwood, et al., 1990; Bransford, Vye, et al., 1990)

5. Support *collaborative construction of knowledge* (Brown, et al., 1989b; Collins, et al., 1989; Young, 1993; Cognition and Technology Group at Vanderbilt, 1990a; Cognition and Technology Group at Vanderbilt, 1993a; Resnick, 1987b; Bransford, Sherwood, et al., 1990)

6. Promote *reflection* to enable abstractions to be formed (Brown, et al., 1989b; Collins, 1988; Collins, et al., 1989; Cognition and Technology Group at Vanderbilt, 1990a; Resnick, 1987b)

7. Promote *articulation* to enable tacit knowledge to be made explicit (Collins, et al., 1989; Collins, 1988; Bransford, Sherwood, et al., 1990)

8. Provide *coaching* and *scaffolding* by the teacher at critical times (Collins, et al., 1989; Collins, 1988; Harley, 1993; Resnick, 1987b; Griffin, 1995; Young, 1993)

9. Provide for *integrated assessment* of learning within the tasks (Young, 1993; McLellan, 1993).

Each of these nine principal elements is reviewed in greater depth in Chapter 3.

Situated cognition: Guidelines for implementation

A critical reading of the principal theorists, and critics, of situated learning has revealed a number of important characteristics which have added to the evolving theory of situated learning. LeCompte and Preissle (1993) contend that: 'The purpose of theories is to help us sort out our world, make sense of it, guide how we behave in it, and predict what might happen next' (p. 120). The question that must now be answered is one pre-empted by the principal proponents of situated learning: 'One of the most persistent educational questions following discussions of situated learning has been: How can these situated theories be operationalized?' (Brown & Duguid, 1993, p. 10).

The next task was to use the theory described in Chapter 2 to inform the design of an interactive multimedia program capable of encapsulating the essence of a situated learning environment. Essentially, could the theory of situated learning be used to develop an instructional design model for the design of interactive multimedia?

Before that could be done, however, it was essential to determine how the theory could guide the design of a learning environment regardless of the medium used. The discussion in the previous chapter has determined, from the literature and research, a list of elements of situated learning in its current form, as it has evolved. The task was to define those characteristics in more detail, and to determine how each of these elements could be implemented into the design of a learning environment.

This chapter begins with a discussion of each of the critical characteristics of situated learning identified in Chapter 2. The discussion frequently draws upon a research base broader than one focused on situated learning itself, and this is to capitalise on the findings to be found in wealth of educational research. For example, while collaboration is an important aspect of situated learning, it has also been researched extensively in its own right in a number of research studies. The discussion here draws on these studies and their findings if they are relevant and enhance the understanding of the characteristic of situated learning, with particular emphasis on computer-based applications. Each section concludes with a specific checklist of items that need to be provided for each of the characteristics, which when combined, will constitute

guidelines for the development of a situated learning environment. The development of the learning environment used in the study is described in Chapter 4. The chapter concludes with the research questions of the study which have resulted from the findings and implications of previous research in the field.

Characteristics of situated learning

In Chapter 2, nine characteristics or elements of a situated learning model were determined from the literature. The key elements of the situated learning model are:

- authentic context that reflect the way the knowledge will be used in real-life

- authentic activities

- access to expert performances and the modelling of processes

- multiple roles and perspectives

- collaborative construction of knowledge

- coaching and scaffolding

- reflection

- articulation

- authentic assessment.

Each of these elements is discussed in greater detail below in order to determine, from the research, the important guiding principles for appropriate implementation. These principles were used to inform the design of a learning environment which encompassed the essential aspects of each characteristic (described in detail in Chapter 4). Where possible, each characteristic has been considered discretely, that is, independently of the whole situated learning framework, using research which is not confined to a situated learning perspective. However, it is the combination of the guidelines for each characteristic, provided at the end of the chapter, which creates a model for the development of situated learning environments.

Authentic context

Authentic context was defined as an element of situated learning in Chapter 2, as shown below in Table 3.1:

Table 3.1: Authentic context as an element of situated learning with supporting authors

No.	Element of situated learning	Supporting authors, researchers and theorists
1.	Provide authentic context that reflect the way the knowledge will be used in real-life	(Brown, et al., 1989b; Collins, 1988; Young, 1993; Winn, 1993; Resnick, 1987b; Moore, et al., 1994; Tripp, 1993; Palincsar, 1989; Harley, 1993; Gabrys, et al., 1993):
	• which preserves the full context of the situation without fragmentation and decomposition	(Brown & Duguid, 1993; Resnick, 1987b; Harley, 1993)
	• which allows for the natural complexity of the real world	(Brown & Duguid, 1993; Collins, et al., 1989; Cognition and Technology Group at Vanderbilt, 1990a; Gabrys, et al., 1993; Cognition and Technology Group at Vanderbilt, 1993c; Cognition and Technology Group at Vanderbilt, 1993a)

Authentic context has been widely discussed in the literature, and there is a wealth of research and writing devoted to assessing its value in an educational context. Jonassen (1991a) contends that context provides 'episodic memory cues that make the acquired knowledge more memorable' (p. 37). Norman illustrates this by pointing out that if someone arranges a meeting with you at 5.30 pm, you do not have to consciously memorise the time, place and person. The details are easily remembered because they fit readily into your cognitive structure. Within learning environments, Rogoff (1984) defines context as 'the problem's physical and conceptual structure as well as the purpose of the activity and the social milieu in which it is embedded' (p. 2). McLellan (1994) as described earlier, points out that context can be: the work setting, a highly realistic surrogate of the work environment, or an anchoring context such as a video or multimedia program.

Simulation programs present situations to students where: the problem itself needs to be identified, there may be a large variety of possible heuristics to use, there may be a number of acceptable solutions, and a sufficiently rich knowledge base is presented to enable complex problems to be solved (Patterson & Smith, 1986, p. 97). Complex computer simulations, such as those used by the military and by aircraft industries were only possible, until recently, when developed with 'supercomputers' and high

performance processors (Forester, 1987). However, the availability of powerful, low cost computers has meant that simulations of real-world environments are now becoming increasingly commonplace in classrooms (Lebow & Wager, 1994).

Simulations vary enormously in the amount of realism they portray, from very simple representations to complex, life-like situations. Rieber (1991) describes an operation created with LOGO where the simple act of naming the turtle a boat and the screen target a whale enables the activity to be described as a whale search simulation. At the other extreme, virtual reality is enabling simulations so realistic that people react spontaneously and automatically to the environment as if they were really experiencing it. For example, McLellan (1991) relates a trainee pilot's experience in an aircraft simulator:

> Part of the drill is that we lose an engine at a critical period in the take-off. And I made the rotation and I did everything I possibly could and the thing rolled to the right and crashed ... I yelled and everybody else yelled ... It is so realistic that it's almost frightening. (p. 33)

Immersive simulations such as this are time consuming and expensive to produce, and it is doubtful that this level of realism is essential in classroom simulations for learning to occur, or that the physical reality of the learning situation is a critical component. Smith (1987) in his review of research related to simulations in the classroom concluded that the 'physical fidelity' of the simulation materials is less important than the extent to which the simulation promotes 'realistic problem-solving processes' (p. 409), a process Smith describes as the 'cognitive realism' of the task (Smith, 1986).

Much research into the realism of learning environments indicates that maximum fidelity does not necessarily lead to maximum effectiveness in learning (Alessi, 1987, cited in Reigeluth & Schwartz, 1989). Many researchers and theorists argue that the natural complexity of many real-life situations is counterproductive to efficient learning. Cunningham (1984), for example, contends that simulations that are too realistic interfere with the underlying educational objectives:

> In constructing the role of police officer, it may not be necessary to include the real-life constraints of traffic jams, panic, job dissatisfaction and the size of the police department ... what could be a learning exercise becomes an effort to understand or administer a complex exercise. (p. 225)

Similarly, Sandberg and Wielinga (1992) believe that such an approach can lead to exceptionally high expectations, and ultimately be counterproductive, with students

simply 'overwhelmed by the complexities of the field' (p. 136). Reigeluth and Schwartz (1989) recommend that the best instructional design for computer-based simulations is one that begins with low fidelity and progresses in fidelity and complexity as the instruction proceeds. These approaches concur with the systems model of instructional design which specifies that the instructional sequence should progress from simple to complex (Gagné, Briggs, & Wager, 1992; Dick & Carey, 1990; Dick, 1991).

However, the tendency to simplify complex cases and situations, particularly in the initial instruction, can impede the later acquisition of more complex understandings (Spiro, Feltovich, Jacobson, & Coulson, 1991b). Spiro, Vispoel, Schmitz, Samarapungavan and Boerger (1987) argue that examples and cases must be studied as they naturally occur 'not as stripped down "textbook examples" that conveniently illustrate some principle' (p. 181). Errors of oversimplification can also compound each other. For example, Feltovich, Spiro and Coulson (1989, cited in Spiro, et al., 1991b) have identified more than twelve serious misconceptions held by the majority of medical students they tested, the origins of which they were able to trace to oversimplification of the initial presentation of the concepts.

Honebein, Duffy and Fishman (1993) argue that it is not necessary to simplify learning environments to enhance learning, and that designing realistic levels of complexity in a learning environment can help to make learning easier. They give the example of a study with students who disliked fractions and who found them difficult to learn. These students were asked to design computer software which would teach fractions to students one year younger than themselves. This meant that the students had to learn what was important about fractions before they could teach it to others. Honebein, et al. note that:

> When the project was complete, the students had learned not only about fractions but also about software design and instructional design ... and were so absorbed by the challenges ... they practically 'forgot' that they were also learning about fractions ... It really can be easier to learn more! (p. 95)

Spiro et al. (1987) also criticise the tendency to oversimplify in learning environments. They accuse such practice as motivated by convenience rather than effectiveness of the learning environment:

> Simplification of complex subject matter makes it easier for teachers to teach, for students to take notes and prepare for their tests, for test-givers to construct and grade tests, and for authors to write texts. The result is a massive 'conspiracy of convenience'. (p. 180).

Is it ever appropriate to simplify contexts in education? Spiro et al. (1991a) concede that simplification may be appropriate when two essential conditions are met: the learning is at an introductory level and it is conducted in a well-structured domain. However, Honebein et al. (1993) argue against oversimplification at any level. They recommend that the complexity of the learning environment should reflect the complexity of the environment expected in the final performance. The aim should therefore be to assist the learner in the functioning in the environment rather than to simplify it. Research and discussion on cognitive load (cf., Oren, 1990; Jih & Reeves, 1992; Stoney & Wild, 1997) is providing guidelines on how this might be achieved. Oren (1990) points out that excessive demands on learners can be reduced by modifying the design of a multimedia program while retaining complexity, for example, by limiting the number of options immediately available for novice users but making them accessible to more advanced users. An example of how this might be achieved in an authentic manner is given by Maor and Phillips (1996) who describe the development of a software package on *Birds of Antarctica*. In order to maintain a complex learning environment, but to avoid an overwhelming inundation of data, students using the program assume a role on board a ship as 'junior researchers'. As their ability in dealing with the instruments and interpretation grows, they move to become 'senior researchers' with access to increasingly more sophisticated variables and data.

Young and McNeese (1993) describe ten attributes of authentic situations or contexts:

1. Coordination of multiple cognitive processes, applied through multiple perspectives;

2. Complex contexts that provide critical perceptual and rich situational affordances;

3. Interpersonal interaction;

4. Group problem solving which requires the social construction of knowledge;

5. Ill-structured content requiring generation of relevant subproblems;

6. Integration of distributed information from various specialties and domains;

7. Extended time frames for problems which cannot be solved in a few minutes or even a few hours;

8. Competing solutions;

9. Possibility to discover problems and notice perceptual attributes of the problems, such as detecting relevant from irrelevant information;

10. Inherent values, intentions and goals that often have personal and social significance (pp. 825-826).

They argue that even contrived situations are 'realistic' if they maintain these ten properties. Similarly, the Cognition and Technology Group at Vanderbilt (1990a) discuss the degree to which anchored instruction is authentic. Their projects are authentic on two levels: authenticity of objects and data in the settings, and authenticity of tasks the students perform (p. 7). Despite, Tripp's (1993) belief that students in these classes are not dealing with real situations—only the actual work setting will suffice—there are a number of theorists in the area who accept McLellan's position that technology-related contexts are acceptable.

Recommended design features

Several implications for practice can be drawn from the research into authentic context. In designing learning environments with authentic contexts, it is not enough to simply provide suitable examples from real-world situations to illustrate the concept or issue being taught. The context must be all-embracing and provide a sustained and complex learning environment that can be explored at length. More specifically, a learning environment which purports to use an authentic context needs to provide:

- a physical environment which reflects the way the knowledge will ultimately be used (Brown, et al., 1989b; Collins, 1988; Young & McNeese, 1993)

- a design to preserve the complexity of the real-life setting with 'rich situational affordances' (Brown, et al., 1989b; Collins, 1988; Young & McNeese, 1993)

- a large number of resources to enable sustained examination from a number of different perspectives (Spiro, et al., 1987; Young & McNeese, 1993; Brown, et al., 1989b; Collins, 1988)

- an editorial policy which makes no attempt to fragment or simplify the environment (Honebein, et al., 1993; Spiro, et al., 1987; Young & McNeese, 1993; Brown, et al., 1989b).

Authentic activities

The opportunity to complete authentic activities was defined as an element of situated learning in Chapter 2, as shown below in Table 3.2.

Table 3.2:　　Authentic activity as an element of situated learning, with supporting authors

No.	Element of situated learning	Supporting authors, researchers and theorists
2.	Provide authentic activities	(Brown, et al., 1989b; Young, 1993; Cognition and Technology Group at Vanderbilt, 1990a; Winn, 1993; Resnick, 1987b; Tripp, 1993; Harley, 1993; Griffin, 1995):
	• which are ill-defined	(Brown, et al., 1989b; Cognition and Technology Group at Vanderbilt, 1990a; Winn, 1993)
	• which promote exploration where students find as well as solve the problems	(Collins, et al., 1989; Collins, 1988; Cognition and Technology Group at Vanderbilt, 1990a; Bransford, Sherwood, et al., 1990; Bransford, Vye, et al., 1990)
	• which provide the opportunity to detect relevant and irrelevant material	(Young, 1993; Cognition and Technology Group at Vanderbilt, 1990a)
	• which allow sustained thinking by exploring topics in depth	(Cognition and Technology Group at Vanderbilt, 1993c; Bransford, Sherwood, et al., 1990; Bransford, Vye, et al., 1990)
	• where tasks can be integrated across subject areas	(Bransford, Vye, et al., 1990; Bransford, Sherwood, et al., 1990)

Activities, investigations and problems are at the heart of student involvement in formal learning contexts. Teachers provide such activities to enable students to interact with the learning environment and to practice newly acquired skills.

Clayden, Desforges, Mills and Rawson (1994) point out that the kind of activities frequently used in classrooms lead to an enculturation into the practices of classrooms rather than the real-world transfer teachers expect. They note that students' efforts to make sense of classroom experiences generally lead them to focus on working practices rather than abstract ideas. 'What they learn from the classroom experience is how to do work, how to be neat, how to finish on time ... and how to tidy away' (p. 164). While these comments are most appropriate for classrooms, the same conclusions may be drawn for the design of much interactive multimedia. Students learn how to invoke 'sub-optimal' schemes to enable them to proceed, rather than deal with the content in a way that promotes true understanding. The approach of many interactive multimedia programs to these activities is to employ a design which provides steps, procedures, hints, suggestions, clues and facts which neatly add up to the 'correct' solution. These

are interspersed within the program, waiting to be discovered by the learner (Herrington & Oliver, 1995a). Many of these programs are so 'well designed', they fail to account for the nature of real-world problem solving, where the solution is rarely neat and the salient facts are rarely the only ones at students' disposal.

In contrast, a number of authors suggest that authentic activities should be ill-defined—students *find* as well as *solve* the problems. Learners need to have the opportunity to explore a resource with all the complexity and uncertainty of the real-world. The learners would have a role in determining the task and how it might be broken up into smaller tasks, selecting which information is relevant, and finding a solution which suits their needs. Several authors have attempted to delineate characteristics of authentic activities. For example, Young (1993) lists the attributes of real-life problems which need, where possible, to be replicated in authentic activities. The problem must provide:

1. Ill structured complex goals,

2. Opportunity for the detection of relevant versus irrelevant information,

3. Active/generative engagement in defining problems as well as solving them,

4. Involvement of the student's beliefs and values,

5. An opportunity to engage in collaborative interpersonal activities (p. 45).

Jonassen (1991b) defines authentic activities as tasks: that have real-world relevance and utility, that integrate those tasks across the curriculum, that provide appropriate levels of complexity and that allow students to select appropriate levels of difficulty or involvement (p. 29). Similarly, Bransford, Vye, Kinzer and Risko (1990) discuss ways to optimise anchored instruction and describe the following criteria of authentic activities which maximise the effectiveness of the approach:

1. A single complex problem should be investigated by the students.

2. Students identify and define their own questions.

3. Students must have the opportunity to experience the problem from a number of different perspectives.

4. Students work on the problem over a 'reasonably long period of time' (p. 394), that is weeks rather than days.

5. Activities are logically related to the problem.

The Cognition and Technology Group at Vanderbilt (1990b) stress the importance of complexity and the necessity to provide an environment capable of sustained examination. They describe authentic tasks as 'generative' because the completion of the task requires the students to generate other problems to be solved. They draw a distinction between these authentic tasks and simple word problems which already define the problem, such as: 'If you travel 150 kilometres at 90 kph, how long will the journey take?'

It is possible to use the findings of the research and writing on authentic activities to produce guidelines for implementation in learning environments, as given in the next section.

Recommended design features

Many of these characteristics of authentic activities overlap with other elements of the situated learning model, (e.g., multiple perspectives), but they do nevertheless provide a useful frame of reference for the elements required in a learning environment featuring authentic activities. Consequently, the learning environment needs to provide:

- activities which have real-world relevance (Jonassen, 1991b; Brown, et al., 1989b; Young, 1993; Winn, 1993; Resnick, 1987b; Cognition and Technology Group at Vanderbilt, 1990a)

- ill-defined activities (Young, 1993; Brown, et al., 1989b; Cognition and Technology Group at Vanderbilt, 1990a; Winn, 1993)

- a single complex task to be investigated by students (Bransford, Vye, et al., 1990; Jonassen, 1991b; Cognition and Technology Group at Vanderbilt, 1990b)

- an opportunity for students to define the tasks and sub-tasks required to complete the activity (Bransford, Vye, et al., 1990; Young, 1993; Cognition and Technology Group at Vanderbilt, 1990b; Collins, et al., 1989)

- a sustained period of time for investigation (Bransford, Vye, et al., 1990; Cognition and Technology Group at Vanderbilt, 1990b)

- the opportunity for the detection of relevant versus irrelevant information, (Young, 1993; Cognition and Technology Group at Vanderbilt, 1990a)

- the opportunity to collaborate (Young, 1993)

- tasks which can be integrated across subject areas (Jonassen, 1991b; Bransford, Vye, et al., 1990; Bransford, Sherwood, et al., 1990).

Expert performance

The opportunity for students to refer to expert performance is another element of situated learning as defined in Chapter 2, and shown below in Table 3.3:

Table 3.3: Expert performance as an element of situated learning, with supporting authors

No.	Element of situated learning	Supporting authors, researchers and theorists
3.	Provide access to expert performances and the modelling of processes	(Collins, et al., 1989; Collins, 1988; Tripp, 1993)
	• which provides opportunities for observation of the task before the student attempts it	(Collins, et al., 1989; Resnick, 1987b)
	• which allow for narratives and stories to be told	(Brown, et al., 1989b; Brown & Duguid, 1993; Lave & Wenger, 1991)
	• which employ the social periphery (legitimate peripheral participation)	(Lave & Wenger, 1991; Brown & Duguid, 1993; Tripp, 1993)

Access to expert performances and the modelling of processes has its origins in the apprenticeship system of learning, where students and craftspeople learned new skills under the guidance of an expert (Collins, et al., 1989). Important elements of expert performances are found in modern applications of the apprenticeship model such as internship (Jonassen, Mayes, & McAleese, 1993), and case-based learning (Riesbeck, 1996).

Expert performances and the modelling of processes, allow students to observe a task before it is attempted. Such access enables narratives and stories to be accumulated, and invites the learner to absorb strategies which employ the social periphery (legitimate peripheral participation) (Lave & Wenger, 1991; Brown & Duguid, 1993). The capabilities and strengths of interactive multimedia are more than adequate to provide a 'window onto practice' (Brown & Duguid, 1993, p. 14). For example, short movies of experts performing skills—such as, a teacher asking open-ended questions, a nurse using reflective listening with a patient, a building adviser assessing foundations, or a farmer judging the quality of produce—allow students the opportunity to observe the experienced practitioner at work. Collins (1989) points out that students often fail to use all the resources at their disposal when solving a problem because they have never observed the processes required. Collins gives the example of students being unable to use good models of writing acquired through their own reading as they have no understanding of the strategies used to produce that text.

An important aspect of expert performances in a learning environment is that it enables the learner to compare his or her performance or understanding to an expert in the field (Collins, et al., 1991; Collins, 1988; Collins & Brown, 1988; Candy, Harri-Augstein, & Thomas, 1985). Collins, Brown and Newman (1989) have also pointed out that it is important for students to be able to compare their performance with others at various levels of expertise. This type of comparison features heavily in another aspect of the situated learning model—reflection, and this aspect is discussed in greater depth in the section on *Reflection* which follows later in this chapter.

Recommended design features

The literature on expert performance described above suggests that the learning environment needs to provide:

- access to expert thinking and modelling processes (Collins, et al., 1989; Collins, 1988; Candy, et al., 1985)

- access to learners in various levels of expertise (Collins, et al., 1989)

- opportunity for the sharing of narratives and stories (Brown, et al., 1989b; Brown & Duguid, 1993; Lave & Wenger, 1991)

- access to the social periphery or the observation of real-life episodes as they occur (Brown, et al., 1989b; Brown & Duguid, 1993; Lave & Wenger, 1991).

Multiple roles and perspectives

Multiple roles and perspectives was identified as an element of situated learning in Chapter 2, as shown below in Table 3.4:

Table 3.4:   Multiple roles and perspectives as an element of situated learning with supporting authors

No.	Element of situated learning	Supporting authors, researchers and theorists
4.	Provide multiple roles and perspectives	(Brown, et al., 1989b; Collins, et al., 1989; Cognition and Technology Group at Vanderbilt, 1990a; Cognition and Technology Group at Vanderbilt, 1993a; Cognition and Technology Group at Vanderbilt, 1993b; Cognition and Technology Group at Vanderbilt, 1993c; Lave & Wenger, 1991; Bransford, Sherwood, et al., 1990; Bransford, Vye, et al., 1990)

Multiple perspectives has been defined as an important cognitive activity that should be promoted in the design of authentic learning environments (Honebein, et al., 1993). In discussing instruction which puts forward a single, 'correct' interpretation, Spiro, Feltovich, Jacobson and Coulson (1991b) contend that 'single perspectives are not *false*, they are *inadequate'* (p. 22). For example, Klein and Hoffman (1993) point out that experience per se does not equal expertise. They cite their own earlier research on firefighters where rural volunteer firefighters with 10 years experience were not as expert as those who had spent one year in a 'decaying inner city' (p. 205). Simple accumulation of practice from a single perspective is not sufficient to ensure expertise.

Young (1993) describes repeated viewing of the film *Young Sherlock Holmes*, suggesting that the use of the same resource for a whole semester invokes images of 'students bored to tears when viewing the film for the tenth or thirteenth time. But ... it was the changes in understanding that proved motivating, not the original presentation of the situation' (pp. 49-50). Clancey (as cited in Sandberg & Wielinga, 1992) believes that complexity helps to enhance a student's understanding of the subject area:

> Instead of simply taking in what is being put forward as the expert view, [students] would become aware of the differences of opinion that characterize the field. For a medical student this would mean asking questions like: If I know something, what other people will know it too—nurses or only particular doctors?' (p. 136)

A medical training example is also given by Honebein, Duffy and Fishman (1993) where teams of interns provide alternative diagnoses as part of the training procedure. Honebein et al. point out such collaborative learning is an important aspect of the generation and evaluation of multiple perspectives.

Spiro, Feltovich, Jacobson and Coulson (1991a) see multiple perspectives as a critical component of their Cognitive Flexibility Theory. They contend that 'visiting the same material at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives is essential for attaining the goals of advanced knowledge acquisition (mastery of complexity and preparation for transfer)' (p. 28). They go on to explain that any single examination of material will fail to notice salient factors which may only be apparent from a different perspective, and possibly then only on the second or third exploration. The 'psychological demands' in the examination of a complex case are too great for students to be able to acknowledge all the relevant connections, particularly for nonadjacent material, without an examination of the material from multiple perspectives.

Spiro, Feltovich, Jacobson and Coulson (1991a) describe a project entitled *Exploring Thematic Structure in Citizen Kane*. Students are able to explore the film Citizen Kane from a number of different predetermined perspectives. For example, instead of accepting that the meaning of the film can be encapsulated in a single agreed upon theme, students can select different themes such as 'wealth corrupts' or 'the hollow, soulless man'. The student can then examine in close proximity five scenes from the film that illustrate this theme. (It is assumed that the student has already seen the film in its entirety.) The student can also access expert commentary once they have viewed the scenes.

In contrast, many interactive multimedia packages are designed in a linear instructional format which assumes that the learner begins at the beginning and works through the program to the conclusion. Giving the learner multiple roles and the opportunities to explore the program from a number of perspectives means that the resource must have an integrity which enables close scrutiny and examination, and may yield fruitful information and rich learning situations, time and again.

Recommended design features

In order for students to be able to investigate the task from more than a single perspective, it is important for the learning environment to provide:

- different perspectives on the topics from various points of view (Brown, et al., 1989b; Collins, et al., 1989; Cognition and Technology Group at Vanderbilt, 1990a; Cognition and Technology Group at Vanderbilt, 1993a; Lave & Wenger, 1991; Bransford, Sherwood, et al., 1990)

- the opportunity to express different points of view through collaboration (Honebein, et al., 1993)

- the opportunity to criss cross the learning environment by providing more than one investigation within a resource sufficiently rich to sustain repeated examination (Spiro, et al., 1991a; Young, 1993; Spiro, et al., 1991b).

Collaboration

Collaboration was identified as an element of situated learning in Chapter 2, as shown below in Table 3.5:

Table 3.5:   Collaboration as an element of situated learning with supporting authors

No.	Element of situated learning	Supporting authors, researchers and theorists
5.	Support collaborative construction of knowledge	(Brown, et al., 1989b; Collins, et al., 1989; Young, 1993; Cognition and Technology Group at Vanderbilt, 1990a; Cognition and Technology Group at Vanderbilt, 1993a; Resnick, 1987b; Bransford, Sherwood, et al., 1990)

Collaboration, and the opportunity to collaboratively construct knowledge, are seen as important elements of a situated learning model. A situated learning environment supports the collaborative construction of knowledge (Bransford, Sherwood, et al., 1990; Brown, et al., 1989b; Young, 1993) but as Hooper (1992) points out, simply placing students in groups will not necessarily result in collaboration. Students must also work on a common task with an appropriate 'incentive structure' (p. 24), that is, identical rewards based on the performance of the group.

For many years, distance educators have investigated and refined the use of computer and communication technologies to solve the paramount problem of the distant learner: isolation. Audioconferencing, videoconferencing, audiographics and live interactive television have been used to provide distance education students with the opportunity to share ideas and negotiate meaning in synchronous interactions. The high cost of implementing these technologies has been balanced by the perceived benefits of teacher-student and student-student collaboration (Latchem, Walsh, & Grant, 1993; Jonassen, et al., 1995). However, while distance educators go to great lengths to promote collaboration, the inherent social benefits of on-campus learning are often neglected by lecturers intent upon students using multimedia programs individually in non-contact time in computer labs, in libraries and increasingly in their own homes and workplaces. The collaborative opportunities so eagerly sought by distance educators are overlooked in the belief that the interactive multimedia program can meet all the learner's needs (Herrington & Oliver, 1996).

Many designers of interactive multimedia design for the isolated and individual learner, and many programs reflect the belief that the interactions will be made by a single user. For example, Alessi (1996) notes that most software is designed with a

single user in mind by asking for just one student's name and storing just one set of data under that name. The wording in such programs implies that a single person is reading the screen. Maor and Taylor (1995) describe the difficulties encountered by teachers attempting to use software designed for individual users and the necessity to create 'unscripted opportunities for student-student negotiations' when students use the materials in groups (p. 841).

For those lecturers who do use the interactive multimedia programs in timetabled classes, it is often the case that the continuing scarcity of resources in education means that students are required to share computers (Chipman, 1993). Group use of computers does not, however, guarantee collaboration. Katz and Lesgold (1993) point out that collaboration is more than cooperation: 'Cooperation ... involves a division of labour in achieving a task. Collaboration happens synchronously; cooperation is either synchronous or asynchronous' (p. 289). Roschelle and Behrend define collaboration as: 'the mutual engagement of participants in a coordinated effort to solve a problem together' (Roschelle & Behrend, 1993, cited in Katz & Lesgold, 1993, p. 289). Jonassen's (1995) discussion of collaboration also emphasises learners' social roles in 'exploiting each other's skills while providing social support and modeling and observing the contributions of each member' (p. 60). Forman and Cazden take this definition even further by suggesting that true collaboration is not simply working together but also 'solving a problem or creating a product which could not have been completed independently' (Forman & Cazden, 1985, cited in Repman, Weller, & Lan, 1993, p. 286).

Research to date has shown that the use of computers per se has a tendency to promote cooperation and collaboration among students and their teachers. Dwyer (1995) reports that in the *Apple Classroom of Tomorrow (ACOT)* study there was a dramatic decrease in teacher-led activities and a corresponding increase in cooperative activities. Collins (1991) lists increased cooperation as one of eight major trends observed in schools that have adopted computers. While there is some support for the notion that computers can provide a useful means to enhance individual 'personalised' knowledge (cf., Ambrose, 1991), a recent evaluation of 60 cooperative learning research studies found that 72% of the studies reported positive outcomes for cooperative activities, while only 8% reported positive outcomes for non-cooperative activities (Slavin, 1989 cited in Repman, et al., 1993). Qin, Johnson and Johnson's (1995) meta-analysis of 63 studies of higher-order learning and problem solving found that cooperative efforts resulted in better problem solving than competitive efforts (in 55, cooperation outperformed competition; in 8, competition outperformed cooperation).

Dunlap and Grabinger (1996) also contend that because complex problems often require unorthodox or unconventional approaches, collaboration allow students to 'share the risk' (p. 79). Many other studies (cf., Slavin, 1996; Del Marie Rysavy & Sales, 1991; Hooper, 1992) have shown that there are clear educational advantages to be derived from collaboration among students.

Recommended design features

Collaboration has much support in the literature as an important design element, not only in its own right, but also as an enabling device for several other characteristics of the situated learning model described in this chapter, such as coaching and articulation. Consequently, the learning environment needs to provide:

- tasks which are addressed to a group rather than an individual (Brown, et al., 1989b; Collins, et al., 1989; Young, 1993; Resnick, 1987b; Alessi, 1996; Maor & Taylor, 1995; Hooper, 1992)

- classroom organisation into pairs or small groups (Hooper, 1992; Fuller, 1996)

- appropriate incentive structure for whole group achievement (Hooper, 1992).

Reflection

Reflection was defined as an element of situated learning in Chapter 2, as shown below in Table 3.6:

Table 3.6:   Reflection as an element of situated learning with supporting authors

No.	Element of situated learning	Supporting authors, researchers and theorists
6.	Promote reflection to enable abstractions to be formed	(Brown, et al., 1989b; Collins, 1988; Collins, et al., 1989; Cognition and Technology Group at Vanderbilt, 1990a; Resnick, 1987b)

Reflection is one aspect of a complex number of interrelated functions which contribute to task performance (Ridley, 1992), an aspect which is gaining increased attention in recent years after almost disappearing from consideration for many years under the influence of learning models which were based on behaviourism (von Wright, 1992). The role of reflection has long been recognised in the military, and in simulations and gaming, as *debriefing* (Thatcher, 1990; Pearson & Smith, 1985)

Boud, Keogh and Walker (1985) define reflection as: 'those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations' (p. 19). These authors stress that such reflection must not occur solely at the unconscious level: 'it is only when we bring our ideas to our consciousness that we can evaluate them and begin to make choices about what we will or will not do' (p. 19). Boud, Keogh and Walker (1985) define the process of reflection as consisting of three closely related stages:

1. *Returning to the experience*: recollecting the salient features of the experience, recounting them to others

2. *Attending to feelings*: accommodating positive and negative feelings about the experience

3. *Re-evaluating the experience*: associating new knowledge, integrating new knowledge into the learner's conceptual framework

Norman (1993) describes two types of thinking that can be used by students in learning environments: experiential and reflective. Collen (1996) draws a distinction between the two, by likening experiential thinking to the rapidly changing images of a music video clip, compared to the concerted mental effort required by reflective thinking. Norman contends that many multimedia learning environments promote experiential thinking at the expense of reflective thinking. The predominance of interactive multimedia programs which require a single user to produce rapid responses to predetermined low-level tasks is an example of the movement towards the acceptance of 'experience as a substitute for thought' (Norman, 1993, p. 15).

Several designers have attempted to provide design elements in multimedia programs which explicitly aim to provide opportunities for students to reflect on learning as they proceed. In a description of REALs (Rich Environments for Active Learning), Dunlap and Grabinger (1996) advise that students should be encouraged to reflect by asking themselves, or by being prompted by the teacher to ask, questions such as: 'Which strategies did you use? Which ones worked? Which ones didn't work? What would you do differently next time? ... What was your single most important difficulty in solving the problem?' (p. 72). This type of reflection corresponds closely with Boud et al's (1985) second stage of *Attending to feelings*.

Gott, Lesgold and Kane (1996) describe programs entitled *Sherlock 1* and *2*, designed to teach specialised electronics troubleshooting in avionics. After the student has solved the troubleshooting problem, he or she can review the activity with a reflective 'walk through' the actions taken. The student can also compare these actions with what an

expert might have done, with options such as a side-by-side listing of an expert's decisions with the most recent decisions produced by the student.

Chee (1995) describes an interactive multimedia project designed using elements of situated learning. The program aims to teach students an object-oriented programming language entitled *Smalltalk*. In order to promote reflection, a *Reflect* button could be selected by students. Question appear which 'either possess deeper conceptual significance, or involve subtleties related to programming practice' (p. 152). For example when the question 'What are the key differences between a class and an instance of that class?' appears, and students have spent time reflecting, they can play a movie of an expert expressing his or her view of the issue. Chee notes: 'In this way, students can gauge to what extent they have come to appreciate the subject domain in the way that an expert does' (p. 154).

However, externally stimulated reflection such as described in these studies may not be integral to the cognitive processes of the students, and if not, is likely to be ignored. Candy, Harri-Augstein and Thomas (1985) believe that reflection is not facilitated simply by allowing time for it, or providing questions or prompts. Kemmis (1985) points out that we do not reflect in a vacuum: 'We pause to reflect ... because the situation we are in requires consideration: how we act in it is a matter of some significance' (p. 141). Such reflection, one might argue, is only possible in a learning environment which provides an authentic task within an authentic context, not at the prompting of an external agent.

Many theorists see reflection as both a *process* and a *product* (Collen, 1996)(Kemmis, 1985), and that it is action oriented (Kemmis, 1985). Knights (1985) contends that reflection is not the kind of activity which its name suggests—a solitary, internal activity—but a two-way process with the aware attention of another person: 'Without an appropriate reflector, it cannot occur at all' (p. 85). This view is strongly supported in the literature by others who point out that reflection is a social process (Kemmis, 1985), and that collaboration on tasks enables the reflective process to become apparent (von Wright, 1992).

The literature on situated learning dwells heavily on one aspect of reflection, possibly at the expense of a broader more useful framework. The most important function of reflection from a situated learning perspective, is that it enables the learner to compare his or her performance or understanding to an expert in the field (Collins, et al., 1991; Collins, 1988; Candy, et al., 1985). Collins, Brown and Newman (1989) have also pointed out that it is important for students to be able to compare their performance

with others at various levels of expertise. It is this ability to compare expertise which is most frequently discussed in the situated learning literature, although recently, McLellan (1996) has advocated a broader view of reflection which incorporates some of the ideas of writers such as Laurel (1993) and Csikszentmihalyi (1992) who respectively speak of 'computers as theatre', and the 'optimal flow' of the learning experience. Both of these writers discuss the concept of 'immersion' where reflection is enhanced by the learner being totally absorbed by the learning environment.

Recommended design features

This review of the research and literature on reflection indicates that, in order to facilitate reflection, the learning environment needs to provide:

- authentic context and task (Brown, et al., 1989b; Norman, 1993)

- the facility for students to return to any part of the learning environment if desired, and to act upon reflection (Boud, et al., 1985; Kemmis, 1985; Collins & Brown, 1988)

- the opportunity for learners to compare themselves with experts (Collins, et al., 1991; Collins, 1988; Collins & Brown, 1988; Candy, et al., 1985)

- the opportunity for learners to compare themselves with other learners in varying stages of accomplishment (Collins, et al., 1989)

- collaborative groupings of students to enable reflection with aware attention (Knights, 1985; von Wright, 1992; Kemmis, 1985).

Articulation

Articulation was defined as an element of situated learning in Chapter 2, as shown below in Table 3.7:

Table 3.7:   Articulation as an element of situated learning with supporting authors

No.	Element of situated learning	Supporting authors, researchers and theorists
7.	Promote articulation to enable tacit knowledge to be made explicit	(Collins, et al., 1989; Collins, 1988; Bransford, Sherwood, et al., 1990)

Counsellors and psychologists have long been aware of the importance of verbalisation in beginning to affect change in problematic behaviours. A frequently quoted psychological law of counselling is 'I learn what I believe as I hear myself speak' (Saunders & Herrington, 1995, p. 8). Similarly, Baktin (1986) contends that 'any true understanding is dialogic in nature' (cited in Brown & Campione, 1994, p. 267). The implication is that the very process of articulating enables formation, awareness, development, and refinement of thoughts.

In education, the work of Vygotsky (cf., Davydov, 1995) has profoundly influenced the way educators see the role of articulation in learning. Vygotsky believed that speech is not merely the vehicle for the expression of the learner's beliefs, but that the act of creating the speech profoundly influences the learning process. Vygotsky wrote: 'Thought undergoes many changes as it turns into speech. It does not merely find expression in speech; it finds reality and form' (cited in Lee, 1985, p. 79). Vygotsky believed that intellectual development occurs first between people in a social context before it is internalised within the individual:

> Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category, and then within the child as an intrapsychological category. (Vygotsky cited in Wertsch, 1985b, p. 60-61)

Accordingly, the process is not a passive one, but a dynamic construction of personal ownership of learning through articulation and reflection (McMahon & O'Neill, 1993). This active process is reflected in Mercer's (1996) comment that: 'Talk is now recognised as more than a means for sharing thoughts: it is a social mode of thinking' (p. 374).

The role of articulation has also been recognised in the value of peer tutoring. Research on peer tutoring (cf., Forman & Cazden, 1985) has suggested that reasoning and problem solving is facilitated by 'cognitive reorganization induced by cognitive conflict' (p. 330). Cognitive conflict occurs when students with disparate viewpoints challenge each other's understanding, and is most likely to occur when students are required to achieve consensus. Pea (1991) describes the importance of publicly defending a position in presentations to critics, who may be other students or specialists and experts on the topic. Pea describes a project where students composed interactive multimedia presentations and where one of the key elements was the argumentation and persuasion of the product. The importance of developing arguments both for and

against the proposal was highlighted, and these arguments were presented in formal presentation open to critiquing. Pea suggests that such activity 'might fundamentally change the nature of learning by creating rich conversational artefacts for discussion and presentation' (p. 65).

Chee (1995) describes an interactive multimedia project designed using elements of situated learning. In order to accommodate articulation as an element as students use the package, the designers of the program included an *Articulate* button. When students click on the button, they are given questions which require them to articulate answers 'either to themselves, or to a friend' (p. 151). Questions include: 'What is the relationship between a class and a subclass? How do you determine the superclass of a new class that you are going to define? What are the differences between the pseudo-variables *super* and *self*? What situation can cause an infinite loop when the method *new* instructional design involved?' (p. 151). Questions such as these, requiring only low-level factual responses, appear to be little more than a revision strategy, totally unlike the rich opportunities articulation affords such as described by Edelson, Pea and Gomez (1996):

> The act of speaking requires an individual to place a structure and a coherency on his or her understanding that may lead the individual to recognize gaps in that understanding or forge new connections between formerly disconnected knowledge. The interaction between speaker and listener(s) in a conversation amplifies this process as they attempt to reconcile the differences in their perspectives, opinions, and experiences ... The social act of attempting to share and reconcile the knowledge of different individuals motivates learning in a way that is much rarer ... among solitary learners. (p. 152)

In spite of this strong argument within research for the value of articulation in learning, many interactive multimedia programs are used quietly where a solitary student taps, selects, points and clicks in silence (Herrington & Oliver, 1995a). Lave and Wenger (1991) point out that being able to speak the vocabulary and tell the stories of a culture of practice is fundamental to learning, yet the use of some interactive multimedia programs allow the knowledge to remain tacit.

Recommended design features

In order to enable opportunities for articulation, the learning environment needs to provide:

- a complex task incorporating inherent, as opposed to constructed, opportunities to articulate (Edelson, et al., 1996; Collins, et al., 1989; Collins, 1988; Bransford, Sherwood, et al., 1990)

- collaborative, groups to enable social then individual understanding (Vygotsky, 1978; Edelson, et al., 1996; Mercer, 1996)

- public presentation of argument to enable articulation and defence of learning (Pea, 1991; Lave & Wenger, 1991).

Coaching and scaffolding

Coaching and scaffolding were defined as important elements of situated learning in Chapter 2, as shown below in Table 3.8:

Table 3.8:   Coaching and scaffolding as elements of situated learning, with supporting authors

No.	Element of situated learning	Supporting authors, researchers and theorists
8.	Provide coaching by the teacher at critical times, and scaffolding and fading of teacher support	(Collins, et al., 1989; Collins, 1988; Harley, 1993; Resnick, 1987b; Griffin, 1995; Young, 1993)

A systems approach to the design of learning environments proposes that the best way to deal with complexity is to simplify the topic by breaking it down into its component parts. However, Perkins (1991b) suggests that the temptation to over-simplify learning environments should be resisted, and instead designers and teachers should search for new ways to provide appropriate scaffolding and support. A situated learning environment provides for coaching at critical times, and scaffolding of support, where the teacher provides the skills, strategies and links that the students are unable to provide to complete the task. Gradually, the support (the scaffolding) is removed until the student is able to stand alone.

The foundation for the notion of scaffolding lay in Vygotsky's (1978) 'zone of proximal development' described as 'the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with

more capable peers' (p. 86). Vygotsky's ideas prompted Bruner and others to develop the notion of scaffolding (Wertsch, 1985a), described more recently by Greenfield (1984) as comprising five salient characteristics. According to Greenfield, scaffolding, in both the building and the educational sense:

1.   Provides a support,

2.   Functions as a tool,

3.   Extends the range of the worker,

4,   Allows the worker to accomplish a task not otherwise possible,

5.   Is used selectively to aid the worker where needed (p. 118).

Many designers of interactive multimedia believe their programs should be self-contained resources that include everything the student needs to learn a particular topic. However, lecturers and lecturers who send students to work individually on interactive multimedia programs are not only denying them the benefits of collaboration, but also the benefits of expert assistance—providing hints, suggestions, critical questions, and the 'scaffolding' to enable them to solve more complex problems.

Some argue that the interactive multimedia program itself can fulfil the coaching role, and some programs are designed to 'eliminate pedagogical roles for teachers', to effectively make them 'teacher-proof' (cf., Reeves, 1993b). There have been some attempts to design interactive multimedia and computer-based instruction which provide inbuilt coaching in certain learning situations (cf., Collins & Brown, 1988; Young, 1995). Lajoie (1993) describes a computer-based environment for avionics troubleshooting entitled Sherlock 1 which is designed to provide coaching:

> Sherlock is designed to offer the least hint that can enable further problem-solving progress ... However, when a trainee can not construct an answer on her own, more elaborate hints are available that support the trainee's problem solving much as a shop supervisor might. (pp. 265-266)

Such computer-based coaching is promising, but would require extremely sophisticated programming techniques for effective support to be offered in the complex learning environments envisaged by proponents of situated learning. Recent efforts have generally resulted in 'fairly crude approximations of the complex, subtle behaviors exhibited by human tutors' (Wilson & Welsh, 1991, p. 7). Collins et al. (1989) point out that coaching is highly situation-specific and is related to problems that arise as students attempt to integrate skills and knowledge, a role that is still best performed

by the teacher. Dreyfus and Dreyfus (1989) insist that: 'Computers will not be first-rate teachers unless researchers can solve four basic problems: how to get machines to talk, to listen, to know and to coach' (p. 139).

Coaching in a situated learning environment, especially when associated with the use of interactive multimedia, requires 'powerful, but different roles for teachers' (Choi & Hannafin, 1995, p. 67), one that requires the interactions with students to occur mainly at the metacognitive level (Savery & Duffy, 1996). Collins (1991) draws an analogy with piano lessons, where the teacher coaches the student, but in this case with the computer rather than the piano as the third party. Harley (1993) points out that this contradicts a common classroom culture: the understanding that 'there is only one way of knowing—the teacher's way' (p. 49). On this point, Jonassen (1993) maintains that unless the teacher initiates the required change in approach, students may continue to use interactive multimedia programs in the same low-level manner they use books, browsing for factual information: 'Knowledge construction usually accedes to reproduction. Typically, there is only one perspective worth memorising—the teacher's—because that is what will be tested. Teachers find it difficult to give up control' (p. 37).

A useful exercise in exploring the role of the lecturer in implementing an interactive multimedia program is to list three essentially different, but frequently observed, approaches, and compare each role with a number of dimensions in the use of interactive multimedia. Table 3.9 shows examples of the types of roles adopted by teachers, typically in tertiary institutions, in using interactive multimedia in the classroom: teacher as transmitter of knowledge, teacher as coach, and teacher as manager (Herrington & Oliver, 1996).

Table 3.9: Three roles of the teacher in the use of interactive multimedia

Dimension of IMM	Teacher as ...		
	Transmitter	Manager	Coach
Time	Timetabled lecture time	Students' own time	Timetabled lecture time and students' own time
Place	Classroom or lecture theatre	Lab, library, student's home	Classroom or computer lab
Size of groups	Whole class	Individuals	Small groups
Activities	Question and answer	Teacher or program designed problems	Student designed investigations
Teaching strategy	Teacher operates the IMM program projected at the front of the class while students watch	Teacher asks students to work with the IMM program individually in their own time	Teacher moves around class providing assistance as students work on IMM program
Teacher activity	Demonstrating, presenting information	Monitoring progress, record keeping, trouble-shooting, removing impediments to progress,	Providing 'scaffolding', aiding students' inquiries
Students' cognitive activity	Listening, writing notes	Reading, completing activities	Reflecting, analysing, planning, problem-solving, collaborating
Potential learning outcomes	Memorisation of knowledge, factual recall	Knowledge, comprehension	Understanding, higher-order learning, transfer

Each position described in Table 3.9 has its own strengths. The transmitter role is a useful mode for modelling the use of a complex program. The manager role is one which encourages self-directed learning and is increasingly useful in universities that are seeking to blur the distinction between internal and external modes of delivery; indeed, many universities are predicating their reforms in the area of reduced contact time on the notion of alternative delivery modes and new approaches to managing students. The teacher as coach is a fundamental and integral part of a learning environment which provides a substantial scaffolding and coaching support for students.

Recommended design features

In order to accommodate a coaching and scaffolding role principally by the lecturer, the learning environment needs to provide:

- a complex, open-ended learning environment (Collins, et al., 1989; Collins, 1988; Resnick, 1987b)

- no attempt to provide intrinsic scaffolding and coaching (Reeves, 1993b; Collins & Brown, 1988; Wilson & Welsh, 1991; Dreyfus & Dreyfus, 1989; Greenfield, 1984)

- flexible suggestions and guidelines to address the needs of the teacher who may wish to optimise the use of resources in a variety of different contexts (Perkins, 1991b; Greenfield, 1984)

- collaborative learning, where more able partners can assist with scaffolding and coaching (Collins, et al., 1989; Collins, 1988; Young, 1993)

- recommendations that the teacher implementing the program is available for coaching and scaffolding assistance for a significant portion of the period of use (Harley, 1993; Collins, 1988; Griffin, 1995; Young, 1993).

Authentic assessment

Authentic, integrated assessment, was defined as an element of situated learning in Chapter 2, as shown below in Table 3.10:

Table 3.10:   Authentic assessment as an element of situated learning with supporting authors

No.	Element of situated learning	Supporting authors, researchers and theorists
9.	Provide for authentic assessment of learning	(Young, 1993; Young, 1995; McLellan, 1993).

Assessment of student learning is an integral and necessary component of any pedagogical model, an aspect discussed extensively in the literature. Conventional assessment procedures, such as standardised tests, have in recent years, been criticised in much of the literature on assessment. For example, Leone Burton (1992) comments on the disservice such tests have done to the discipline of mathematics:

> If the Oxford Dictionary is to be believed, assessment is the estimation of value for the purpose of fixing and imposing a fine! Norm-referenced, summative

assessment has imposed a fine on millions of learners of mathematics by failing them, and has done a disservice to the discipline by reifying those who succeed and the mathematics on which their success is based. (p. 1)

Many such writers argue that it is futile to apply standardised, norm-referenced tests to the assessment of learning in constructivist learning environments. For example, Entwhistle, Entwhistle and Tait (1993) contend that assessment procedures profoundly affect the way students learn, and that 'providing a constructivist teaching environment will have little effect on the quality of learning while conventional assessment procedures remain in place' (p. 353). Young (1993) also notes that 'assessment can no longer be viewed as an add-on to an instructional design or simply as separate stages in a linear process of pre-test, instruction, posttest; rather assessment must become an integrated, ongoing, and seamless part of the learning environment' (p. 48).

This view is supported by Gardner (1992) who maintains that norm-referenced, formal tests and assessment materials are not sensitive enough to account for cultural differences, and they are rarely useful in determining students' level of competence. As evidence, he cites the work of some of the researchers into learning in context (e.g., Lave & Wenger, 1991; Lave, et al., 1984; Rogoff, 1984; Scribner, 1984) and points out that these studies have revealed that often those who fail on formal measures of calculating or reasoning are able to exhibit excellent command of the same skills in their everyday context.

Many interactive multimedia programs are used extensively in units and classes, but students continue to be assessed by the conventional methods of norm-referenced tests, essays and examinations which are generally based on the assumption that there is an objective reality which can be judged right or wrong. Thus, testing items must, of necessity, be confined to simple multiple choice or other low level means to assess students' knowledge.

Other assessment practices used with interactive multimedia have also been called into question. Despite a wealth of research to show that there are clear educational advantages to be derived from collaboration (e.g., Dwyer, 1995; Qin, et al., 1995; Del Marie Rysavy & Sales, 1991), assessment strategies that exploit the use of group work are seldom embedded within computer software products. The focus is on each student learning, and being assessed, independently of the social context in which that learning takes place. The issue of students being graded individually while working collaboratively has also been raised. Young (1995) argues that it is misleading to judge

students individually when one of the most important skills they develop is 'the ability to distribute wisely problem-solving tasks among members of a group' (p. 91). Hooper (1992) also believes that there is little incentive for cooperation when students within a group compete for grades.

As alternatives to norm-referenced, standardised tests McLellan (1993) suggests that assessment can take the form of a number of evaluation measures which do not include formal tests, such as portfolios, summary statistics of learners' paths through multimedia programs, diagnosis, and reflection and self-assessment. There also exists extensive literature into *authentic* and *performance-based* assessment as a more valid means to assess learning. Lajoie (1991) argues that more authentic assessment is required to assess the learning that students might actually carry out in the real world, as opposed to the kind of tasks traditionally learned in classrooms. For example, Wiggins (1990) draws comparisons with 'traditional' types of assessment to help clarify the distinction. Table 3.11 summarises Wiggins' differentiation of authentic and traditional assessment.

Table 3.11:   A comparison of authentic and traditional assessment (Wiggins, 1990)

Authentic assessment	Traditional assessment
Direct examination of student performance on worthy intellectual tasks	Relies on indirect or proxy items
Requires students to be effective performers with acquired knowledge	Reveals only whether students can recognise, recall or 'plug in' what was learned out of context
Present the student with a full array of tasks	Conventional tests are usually limited to pencil-and-paper, one-answer questions
Attend to whether the student can craft polished, thorough and justifiable answers, performances or products	Conventional tests typically only ask the student to select or write correct responses - irrespective of reasons
Achieves validity and reliability by emphasising and standardising the appropriate criteria for scoring varied products	Traditional testing standardises objective 'items' and the one 'right' answer for each
'Test validity' should depend in part upon whether the test simulates real-world 'tests' of ability	Test validity is determined by matching items to curriculum content
Involves ill structured challenges that help students rehearse for the complex ambiguities of professional life	Traditional tests are more like drills, assessing static and too-often arbitrary elements of those activities

A common definition of authentic assessment is one such as given by Torrance in the introduction to the edited papers entitled *Evaluating Authentic Assessment*:

'Authentic assessment' is a generic term which is gaining international currency to describe a range of new approaches to assessment. The basic implication of the term seems to be that the assessment tasks designed for students should be more practical, realistic and challenging than what one might call 'traditional' paper-and-pencil tests. (Torrance, 1995, p. 1)

Such a definition would appear to cover the general meaning of a variety of terms used in the literature to describe alternative forms of assessment, such as *authentic assessment, performance-based assessment, school-based assessment, portfolio assessment* and *coursework assessment.* There has been some discussion in the literature about the distinction that can be drawn between *authentic* and *performance-based* assessment. Many authors use the terms interchangeably (cf., Torrance, 1995) but Reeves and Okey (1996) point out the critical difference is one of the degree of authenticity required in the assessment—the 'fidelity' of the task to the conditions under which the performance would normally occur. Meyer (1992) draws a useful distinction between the two by pointing out that while performance assessment focuses on the student response that is to be examined, authentic assessment, while referring to the performance, focuses on the context in which the response is performed. Meyer notes that using this framework, 'it is difficult to imagine an authentic assessment which would not also be a performance assessment' (p. 40).

Using the principal readings noted above, and other theorists in the field, an attempt has been made to list the essential characteristics of authentic and performance assessments, and to group them into four categories: context, the student's role, authentic activity and indicators. Using these guidelines, assessment is most likely to be authentic if it satisfies the following criteria:

Context:
- Requires fidelity of context (Meyer, 1992; Reeves & Okey, 1996; Wiggins, 1993)

Student's role
- Requires students to be effective performers with acquired knowledge, and to craft polished, performances or products (Wiggins, 1990; Wiggins, 1993; Wiggins, 1989)

- Requires significant student time and effort in collaboration with others (Linn, Baker, & Dunbar, 1991; Kroll, Masingila, & Mau, 1992)

Authentic task
- Involves complex, ill structured challenges that require judgement, and a full array of tasks (Wiggins, 1990; 1993; 1989; Linn, et al., 1991; Torrance, 1995)

- Requires the assessment to be seamlessly integrated with the activity (Reeves & Okey, 1996; Young, 1995,)

Indicators

- Provides multiple indicators of learning (Lajoie, 1991; Linn, et al., 1991)

- Achieves validity and reliability with appropriate criteria for scoring varied products (Wiggins, 1990; Lajoie, 1991; Resnick & Resnick, 1992)

Table 3.12 below summarises the principal characteristics, and distinguishes between authentic and performance assessment by providing an indication of the characteristics appropriate to each.

Table 3.12:   Characteristics of authentic and performance assessment

Authentic assessment ←——————————————————————————————→						
	Performance assessment ←————————————————————→					
Requires fidelity of context	Requires students to be effective performers with acquired knowledge, and to craft polished, performances or products	Requires significant student time and effort in collaboration with others	Involves complex, ill structured challenges that require judgement, and a full array of tasks	Requires the assessment to be seamlessly integrated with the activity	Provides multiple indicators of learning	Achieves validity and reliability with appropriate criteria for scoring varied products
Context	Student's role		Authentic task		Indicators	

One of the principal criticisms of authentic and performance assessment is that validity is achieved at the expense of reliability (Wolf, 1995). Linn, Baker and Dunbar (1991) identify eight dimensions against which the validity of performance-based assessments can usefully be judged, such as fairness, cognitive quality, meaningfulness and cost and efficiency. It is much more difficult, however, to ensure reliability of assessment, and Linn et al. state that 'greater reliance on judgemental reviews of performance tasks is inevitable' (p. 18). This may be a greater problem in large-scale assessment used for accountability, such as in secondary schools, than for smaller, context-specific purposes commonly found in tertiary institutions (Gipps, 1995) and where the learning and the assessment are essentially inseparable such as in individual classes (Reeves & Okey, 1996). Gipps (1995) has pointed out, however, that standardised tests, even in large-scale assessments, do not necessarily guarantee greater reliability. She cites a national standardised reading and comprehension test in

the UK where a remark of the test corresponded to the original in only 55% of the cases; a spelling test remark was 72%. In contrast, the inter-rater reliability on a performance-based mathematics test was higher than on a written test. Clearly, the evidence is not definitive for either case.

Two frequently cited criticisms of authentic assessment (Reeves & Okey, 1996) are that authentic assessment does not allow easy comparisons among students, and it does not provide information about generalisability to other contexts. Reeves and Okey concede that the first criticism is a valid one, and one which must be resolved by a more general consensus about the purpose of assessment. The second concern regarding generalisability, Reeves and Okey contend, is one which proponents of authentic assessment would dismiss on the grounds that they *deliberately* seek to situate learning within the context of the real world, 'a world in which the much vaunted generalizability of standardized tests may have little relevance' (p. 193). This theme is supported by Young (1995) who believes that assessment needs to be viewed in a more functional manner and validated, not solely by its stability as a psychometric instrument, but more critically by its real-world usefulness.

Recommended design features

In order to provide authentic assessment of student learning, and essentially using the criteria established in Table 3.12, the learning environment needs to provide:

- fidelity of context (Meyer, 1992; Reeves & Okey, 1996; Wiggins, 1993)

- the opportunity for students to be effective performers with acquired knowledge, and to craft polished, performances or products (Wiggins, 1990; Wiggins, 1993; Wiggins, 1989)

- significant student time and effort in collaboration with others (Linn, et al., 1991; Kroll, et al., 1992,)

- complex, ill structured challenges that require judgement, and a full array of tasks (Wiggins, 1990; 1993; 1989; Linn, et al., 1991; Torrance, 1995)

- the assessment to be seamlessly integrated with the activity (Reeves & Okey, 1996; Young, 1995,)

- multiple indicators of learning (Lajoie, 1991; Linn, et al., 1991)

- validity and reliability with appropriate criteria for scoring varied products (Wiggins, 1990; Lajoie, 1991; Resnick & Resnick, 1992; Young, 1995; Hooper, 1992).

Guidelines for implementation of situated learning model

The previous literature review has helped to distinguish implementation guidelines for each of the critical elements of situated learning defined in Chapter 2. The presentation of nine elements above is not to suggest that such characterisation is finite and fixed. Further research will inevitably provide refinement and enlightenment on the optimum combination of characteristics of effective learning environments. However, the integrated nature of the elements suggest that such characteristics reflect the essence of real life learning, and work together to enable successful learning to occur in the classroom. The removal of any one element would not necessarily disable the model but would inevitably make the operationalisation of other elements more difficult.

A summary and checklist of the guidelines is given below in Table 3.13. The combined guidelines provide a useful, integrated model for the instructional design of a learning environment which enables the situated elements to be operationalised.

Table 3.13:   Guidelines for implementation of a situated learning model

Element of situated learning	Guidelines for implementation
Provide authentic context that reflects the way the knowledge will be used in real-life	❐ a physical environment which reflects the way the knowledge will ultimately be used (Brown, et al., 1989b; Collins, 1988; Young & McNeese, 1993) ❐ a design to preserve the complexity of the real-life setting with 'rich situational affordances' (Brown, et al., 1989b; Collins, 1988; Young & McNeese, 1993) ❐ a large number of resources to enable sustained examination from a number of different perspectives (Spiro, et al., 1987; Young & McNeese, 1993; Brown, et al., 1989b; Collins, 1988) ❐ an editorial policy which makes no attempt to fragment or simplify the environment (Honebein, et al., 1993; Spiro, et al., 1987; Young & McNeese, 1993; Brown, et al., 1989b).
Provide authentic activities	❐ activities which have real-world relevance (Jonassen, 1991b; Brown, et al., 1989b; Young, 1993; Winn, 1993; Resnick, 1987b; Cognition and Technology Group at Vanderbilt, 1990a) ❐ ill-defined activities (Young, 1993; Brown, et al., 1989b; Cognition and Technology Group at Vanderbilt, 1990a; Winn, 1993) ❐ a single complex task to be investigated by students (Bransford, Vye, et al., 1990; Jonassen, 1991b; Cognition and Technology Group at Vanderbilt, 1990b) ❐ an opportunity for students to define the tasks and sub-tasks required to complete the activity (Bransford, Vye et al., 1990; Young, 1993; Cognition and Technology Group at Vanderbilt, 1990b; Collins, et al., 1989; Collins, 1988) ❐ a sustained period of time for investigation (Bransford, Vye, et al., 1990; Cognition and Technology Group at Vanderbilt, 1990b) ❐ the opportunity for the detection of relevant versus. irrelevant information, (Young, 1993; Cognition and Technology Group at Vanderbilt, 1990a) ❐ the opportunity to collaborate (Young, 1993) ❐ tasks which can be integrated across subject areas (Jonassen, 1991b; Bransford, Vye, et al., 1990; Bransford, Sherwood, et al., 1990)

Element of situated learning	Guidelines for implementation
Provide access to expert performances and the modelling of processes	☐ access to expert thinking and modelling processes (Collins, et al., 1989; Collins, 1988) ☐ access to learners in various levels of expertise (Collins, et al., 1989) ☐ opportunity for the sharing of narratives and stories (Brown, et al., 1989b; Brown & Duguid, 1993; Lave & Wenger, 1991) ☐ access to the social periphery or the observation of real-life episodes as they occur (Brown, et al., 1989b; Brown & Duguid, 1993; Lave & Wenger, 1991)
Provide multiple roles and perspectives	☐ different perspectives on the topics from various points of view (Brown, et al., 1989b; Collins, et al., 1989; Cognition and Technology Group at Vanderbilt, 1990a; Cognition and Technology Group at Vanderbilt, 1993a; Lave & Wenger, 1991; Bransford, Sherwood, et al., 1990) ☐ the opportunity to express different points of view through collaboration (Honebein, et al., 1993) ☐ the opportunity to criss cross the learning environment by providing more than one investigation within a resource sufficiently rich to sustain repeated examination, (Spiro, et al., 1991a; Young, 1993; Spiro, et al., 1991b)
Support collaborative construction of knowledge	☐ tasks which are addressed to a group rather than an individual (Brown, et al., 1989b; Collins, et al., 1989; Young, 1993; Resnick, 1987b; Alessi, 1996; Maor & Taylor, 1995; Hooper, 1992) ☐ classroom organisation into pairs or small groups (Hooper, 1992; Fuller, 1996) ☐ appropriate incentive structure for whole group achievement (Hooper, 1992).
Promote reflection	☐ authentic context and task (Brown, et al., 1989b; Norman, 1993) ☐ the facility for students to return to any element of the program if desired, and to act upon reflection (Boud, et al., 1985; Kemmis, 1985; Collins & Brown, 1988) ☐ the opportunity for learners to compare themselves with experts (Collins, et al., 1991; Collins, 1988; Collins & Brown, 1988) ☐ the opportunity for learners to compare themselves with other learners in varying stages of accomplishment (Collins, et al., 1989) ☐ collaborative groupings of students to enable reflection with aware attention (Knights, 1985; von Wright, 1992; Kemmis, 1985)

Element of situated learning	Guidelines for implementation
Promote articulation	☐ a complex task incorporating inherent, as opposed to constructed, opportunities to articulate (Edelson, et al., 1996; Collins, et al., 1989; Collins, 1988; Bransford, Sherwood, et al., 1990) ☐ collaborative, groups to enable social then individual understanding (Vygotsky, 1978 ; Edelson, et al., 1996; Mercer, 1996) ☐ public presentation of argument to enable articulation and defence of learning (Pea, 1991; Lave & Wenger, 1991)
Provide coaching and scaffolding	☐ a complex, open-ended learning environment (Collins, et al., 1989; Collins, 1988; Resnick, 1987b) ☐ no attempt to provide intrinsic scaffolding and coaching (Reeves, 1993b; Collins & Brown, 1988; Wilson & Welsh, 1991; Dreyfus & Dreyfus, 1989; Greenfield, 1984) ☐ flexible suggestions and guidelines to address the needs of the teacher who may wish to optimise the use of resources in a variety of different contexts (Perkins, 1991b; Greenfield, 1984) ☐ collaborative learning, where more able partners can assist with scaffolding and coaching (Collins, et al., 1989; Collins, 1988; Young, 1993) ☐ recommendations that the teacher implementing the program is available for coaching and scaffolding assistance for a significant portion of the period of use (Harley, 1993; Collins, 1988; Griffin, 1995; Young, 1993)
Provide for authentic assessment of learning	☐ fidelity of context (Meyer, 1992; Reeves & Okey, 1996; Wiggins, 1993) ☐ the opportunity for students to be effective performers with acquired knowledge, and to craft polished, performances or products (Wiggins, 1990; Wiggins, 1993; Wiggins, 1989) ☐ significant student time and effort in collaboration with others (Linn, et al., 1991; Kroll, et al., 1992,) ☐ complex, ill structured challenges that require judgement, and a full array of tasks (Wiggins, 1990; 1993; 1989; Linn, et al., 1991; Torrance, 1995) ☐ the assessment to be seamlessly integrated with the activity (Reeves & Okey, 1996; Young, 1995,) ☐ multiple indicators of learning (Lajoie, 1991; Linn, et al., 1991) ☐ validity and reliability with appropriate criteria for scoring varied products (Wiggins, 1990; Lajoie, 1991; Resnick & Resnick, 1992; Young, 1995; Hooper, 1992)

Situated learning guidelines applied to interactive multimedia

The guidelines presented in Table 3.13 above can be applied to the design of a situated learning environment regardless of medium. When applied to the design of interactive multimedia, the software itself comprises just one aspect of the learning environment. The guidelines cannot all be designed into the software itself. Some of the elements are dependent on the lecturer to provide at the implementation, and some elements are provided by the students themselves. This interaction of overlapping areas of influence is grounded in the literature. For example, Lave and Wenger (1991) base much of their work on situated learning on a conception of learning that is centred on the whole person, resulting from the interaction of three areas of influence: *agent*, *activity*, and *world*. Similarly, Brofenbrenners's (1979) *person*, *process* and *context* approach (as cited in Ceci & Ruiz, 1993) provides a similar framework for cognitive assessment of everyday intelligent behaviour.

In terms of the instructional design of interactive multimedia, the critical characteristics of situated learning can also be examined within a framework of the roles and responsibilities of three mutually constitutive influences: *the learner, the implementation* and *the interactive multimedia program* (Figure 3.1).
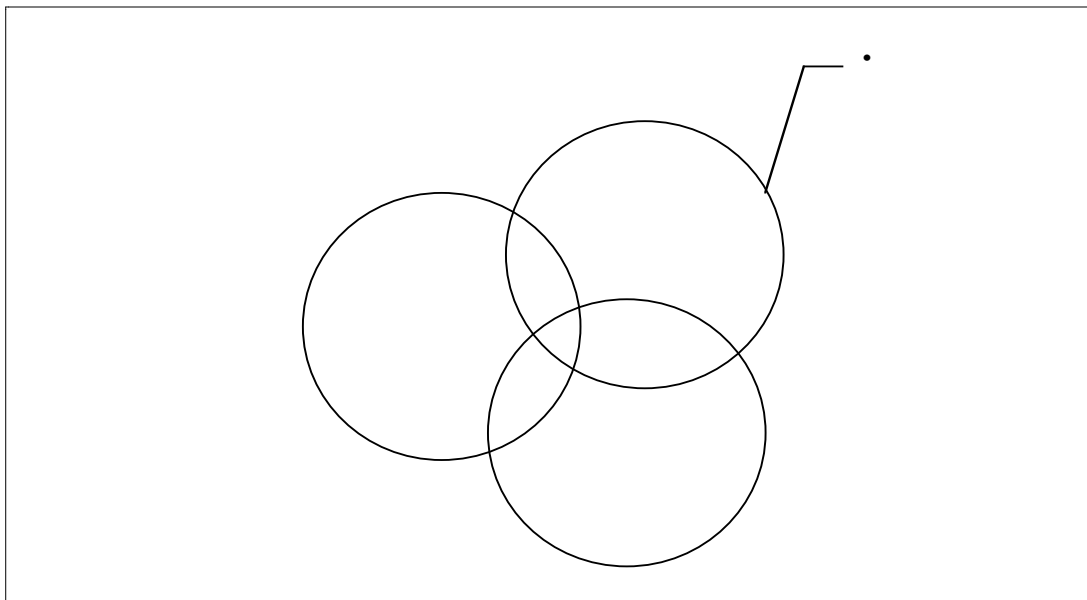
Figure 3.1:   Constitutive elements of situated learning in interactive multimedia

It is important when designing interactive multimedia to consider all three interacting and overlapping elements. It is not enough to produce software which incorporates elements of the situated learning model within its design, without thought for how it could be used by the students or how it might be implemented to support the learning process. Some educators, such as Squires (1996) have spoken of programs designed from a constructivist philosophy being used in very non-constructivist settings. Young, Nastasi and Braunhardt (1996) relate their experience of implementing 'a constructivist design in a constructivist manner' (p. 121). Clearly, the software itself is but one aspect of an interrelating group of influences which may determine whether learning is successful.

Given that not all the elements of the situated learning model are within the control of the producers of the software, consideration must be given to ensuring that the remaining elements are *enabled* (that is, not prevented from occurring by restricted design practices), and that advice and recommendations for use are provided for both students and lecturers using the package. Consideration of these factors has been made within the guidelines given above.

Research questions

The literature review presented here and in Chapter 2, has raised pertinent questions relating to the design of interactive multimedia and the theoretical basis of situated learning as a viable alternative to the behavioural models frequently encountered.

The purpose of this study was to define the critical characteristics of situated learning environments, and to develop a framework for the design of interactive multimedia to embrace these elements. The study attempted to determine the quality of higher-order thinking used in an interactive multimedia program designed to incorporate these critical characteristics of situated learning. The study also investigated student responses to the design elements based on the critical characteristics of situated learning, and the extent of transfer of knowledge to classroom practice.

This thesis reports on the findings of four studies (described in detail in Chapter 5) into how students use an interactive multimedia learning environment based on a model of situated learning. The studies aimed to answer the following research questions:

1.   How do students use an interactive multimedia program designed to incorporate the characteristics of a situated learning environment?

2.   How important to students is each of the critical characteristics of situated learning in the interactive multimedia learning environment?

3.   What types of higher-order thinking do students employ while using an interactive multimedia program based on principles of situated learning?

4.   How effective is an interactive multimedia program based on principles of situated learning in promoting transfer of knowledge to classroom practice?

Development of the software

Before any data could be collected to provide answers to the research questions, it was necessary to design an interactive multimedia program and learning environment based on the situated learning model described in this chapter. The development of the software program is described in Chapter 4.

Development of the learning environment

Once the critical characteristics for a situated learning environment, and guidelines for their implementation, were established, the next stage was to develop an interactive multimedia program which incorporated the critical elements. This chapter describes the process of developing the program. All the critical characteristics of the situated learning model were incorporated into the program itself, or into the program's implementation in the classroom, in order that the theory could be properly investigated.

Selecting the content area

A complete instructional package was needed to incorporate the critical elements of a situated learning environment.

While the content area for the development of the program was not critical, the domain of mathematics education was chosen and proved to be particularly appropriate. The lack of transfer of pedagogical skills from the theory of teacher training to the practical reality of the classroom has been a source of concern to teacher educators for some time. Several writers have expressed concern that despite the emphasis in teacher education courses on 'reformist' methods of teaching mathematics, teachers frequently revert to methods of teaching derived solely from their own experiences as students (Ball, 1994; Lampert & Ball, 1990). Others have noted that preservice teachers' experiences in classrooms during their practicum have proved inadequate because often students observe teaching 'driven by texts and tests', or are ill equipped to detect the subtle differences between quality and mediocre teaching (Mousley & Sullivan, 1995). Despite the variety of innovative and effective assessment techniques, teachers generally continue to limit their means of assessment to a narrow range of pencil-and-paper methods (National Council of Teachers of Mathematics, 1995; Australian Education Council, 1991).

It was decided that the situated learning model would be used to produce a resource to address these concerns. The resource would focus on assessment strategies in

mathematics classrooms (K-12), and it would be designed primarily for a target group of undergraduate preservice teachers.

Instructional design and choice of media

While the primary focus of media in the study was interactive multimedia, it was important to ensure that multimedia was appropriate to the task, and that there was no danger of embarking upon an expensive and time-consuming development process when a more simple combination of media elements would be more effective. The instructional design process, therefore began with an examination of the goals of the exercise, and a consideration of alternative approaches to achieve those goals.

In order to produce an effective learning environment on the issue of assessment in mathematics, which also fulfilled the requirements of the situated learning model, it was necessary to provide preservice teachers with the experience of observing expert teachers using different types of assessment in classrooms. It was also important for the preservice teachers to be able to talk to the teachers about why and under what conditions they used each particular strategy and to be able to ask school children how they felt about them. They also needed to have access to informed comment by experts and to the thoughts of other learners with varying degrees of skill (Collins, et al., 1989).

McLellan (1993) points out that according to the situated learning model, authentic context can be represented in the actual work setting, a highly realistic or 'virtual' surrogate of the actual work environment or an anchoring context such as a video or multimedia program (p. 8).

In order to use the first method, the actual work setting, it would have been necessary to take groups of preservice teachers to a large number of schools and to have them observe many expert teachers in their classes (in addition to their professional practice). They could interview the teachers and their students after the class. This scenario would have provided an excellent representation of the situated learning model, although Spiro, Feltovich, Jacobson and Coulson (1991a) contend that learning a complex concept from 'erratic exposures to complex instances with long periods of time separating each encounter, as in natural learning from experience, is not very efficient' (p. 30). The logistics of organising the preservice teachers was also highly problematic in that they would need to observe a large number of cases. The imposition such an arrangement would make on normal classroom practice, together with the difficulty in locating a sufficient number of teachers who could model the range of strategies, made it a totally impractical option.

Thus, the actual work setting was not an option for this learning situation. The second context recommended by McLellan (1993) as acceptable for situated learning, a 'virtual surrogate' of the actual work environment (such as aircraft simulators) was also ruled out very quickly on the basis of prohibitive costs of development, and lack of resources within the university for use of the finished resource. The situated learning environment had to be useable by a large number of students simultaneously, and in a relatively accessible platform. The anchoring context seemed the most viable.

A video, or series of videos, as an anchoring context was rejected because of the linear format which could not provide ready student access to the scenarios and interviews. Audio-tape and text did not provide the appropriate visual elements to allow peripheral observation of the authentic classroom context, important elements in real-life learning.

One medium that did not have the restrictions of the others was computer-based multimedia. The combination of video clips, sound, text and graphics meant that interactive multimedia was capable of supporting 'the kinds of more intimate, supportive, learning environments called for by the constructivist perspective' (Perkins, 1991a, p. 22), and presenting it in an efficient and accessible format. Multimedia would also enable a 'criss-crossing of the conceptual landscape' in such a way that relevant examples can be explored in close-proximity to each other (Spiro, et al., 1991a, p. 30). In addition, several exemplary published packages within Australia—notably *Investigating Lake Iluka* (1993), *Exploring the Nardoo* (1996), and *Learning about Teaching* (Mousley, Sullivan, & Mousley, 1996)—provided valuable models for the development of successful multimedia learning environments. It was decided to use computer-based interactive multimedia as the vehicle for the situated learning environment to address the concerns expressed by the content experts.

Requirements of the program

In accordance with the situated learning model, preservice teachers using the program to investigate assessment strategies would need to be able to observe experienced teachers in the field demonstrating a range of strategies and techniques, and to then reflect on the most appropriate strategy to use in a particular situation.

Video clips of classroom scenes and interviews appeared to be an appropriate means to provide such opportunities to the students who would use the program. Bransford, Vye, Kinzer and Risko (1990) advocate that the use of video clips have a number of advantages over printed media, and the graphics and animation of computer-based

programs because they provide a much richer source of information. Gestures, affective elements, scenes and music accompanying the dialogue mean that there is much more to notice, and it is possible to find relevant issues which are embedded within the real-life context which might otherwise go unnoticed. Incorporating video clips into the interactive multimedia program would enable students to experience the classroom almost as if it were first hand, but without any of the inherent problems and dangers. Klein and Hoffman (1993) in a discussion on the development of expertise contend that exposing students to 'manufactured experiences' is one of the best ways to increase the development of perceptual-cognitive skills. They argue that computer technology is able to provide 'low-cost and high-fidelity' experiences that can speed the acquisition of expertise (p. 217). The two important advantages of using computer-based material are firstly, that the technology allows the learners to sharpen their ability to discriminate by providing them with a number of situations that are similar but subtly different. Secondly, the student is able to practise on a wide variety of situations and configurations which allows a better development of assessment skills and to 'quickly size up a situation' (p. 217).

Other important requirements of the program were that the context would need to be situated in a real or simulated classroom, and authentic activities could require students to address the problems of assessment and to select their own alternatives to paper and pencil tests. The elements of the model which need to be provided by the learner, such as articulation and collaboration, could also be adequately catered for in the use of the interactive multimedia in the classroom.

In the light of these considerations, the situated learning model, developed and described in Chapter 3, seemed to have a great deal of promise as an instructional design framework to address the problems in the area of assessment in mathematics education. Drawing upon the characteristics of a situated learning environment, and the requirements of the content area of assessment, consideration was given to the media elements which would comprise the multimedia program. It was essential to provide multiple perspectives on assessment, and in so doing, focus strongly on the classroom experience. On this basis, teachers' and children's views on assessment, for example, were included but principals' and parents' views were not. More pragmatic considerations also influenced the final selection of elements; for example, copyright implications restricted the planned inclusion of published articles on assessment strategies.

On this basis, the elements included in the final program were:

1. A computer program on the issue of assessment in mathematics education incorporating:

    - *Video clips of teachers using various assessment technique*s within their classrooms with original sound, in order to show an authentic example of particular assessment strategies being used in a real classroom;

    - *Video clips of teachers' comments of the strategies*, to present the teachers' own reflections on the strengths and weaknesses of each approach;

    - *Video clips of children's comments on the strategies* to present their own feelings and thoughts, and whether they liked and disliked each approach;

    - *Interviews with experts in the field* to provide theoretical perspectives;

    - *Reflections by third year preservice teachers* to provide practical advice from the perspective of students whose experience is only slightly more advanced than the students who would use the resource;

    - *Text descriptions* of each assessment category to provide a simple description of each strategy together with practical advice on its implementation in different classroom situations;

    - *Teacher and children work samples* to enable students to scrutinise work presented in the scenarios;

    - *An electronic notebook* within the program to enable students to copy text from files and to write their own reflections and ideas;

    - *Problems and investigations* to enable the students to examine the resource within authentic tasks.

2. An instruction book for facilitators and students on how to use and implement the resource, which would also provide advice on the situated learning elements not included in the program itself (such as collaboration and articulation).

The development of the program

Two content experts from mathematics education were integral to the development of the program. They conducted a review of the literature on assessment, and from their reading of current issues in the field, identified over 20 categories of assessment relevant to both primary and secondary mathematics classrooms. This was done with the assistance of two external academics, one with experience in multimedia

development in mathematics education, the other knowledgeable in the area of assessment in mathematics.

Once the parameters of the content area had been sketched out, the elements of the multimedia program had to be determined. Using the issue of assessment, the resource was designed to provide preservice primary and secondary mathematics teachers with a number of classroom-based episodes in a multimedia format. In order to produce these resources, it was essential to utilise the skills of a variety of experts, and a team was assembled to oversee the development of the interactive multimedia program.

The development team

The development team was assembled to design and produce the multimedia program. It was a typical team for a project of this nature and consisted of:

- Two content experts: mathematics education lecturers from the Faculty of Education

- Instructional designer

- Instructional technology consultant.

This core group met regularly and tracked the progress of the entire project. Project management was completed by the principal content expert. Responsibility for instructional design, which was critical for the research, was undertaken by the researcher. The expertise of the following professionals was also utilised, generally on a contract basis, at various points during the production phase:

- Two external academics (content experts)

- Computer programmer

- Computer graphic designer and graphic artist

- Video producer and sound recordist.

When the team was in place, and available expertise determined, the interface for the program was designed and the elements of the interactive multimedia package were produced.

Interface design

Once the required media elements and instructional design requirements were mapped out, the interface was designed. The interface needed to provide an effective vehicle for students to interact intuitively with large amounts of information in different forms of media. It also needed to provide convenient access to navigational means to enable them to move freely from one area of the resource to another.

The most straightforward design was to employ a series of buttons to represent the various media elements. As each button was clicked, the relevant video or text item would appear in the screen area (see Figure 4.1).
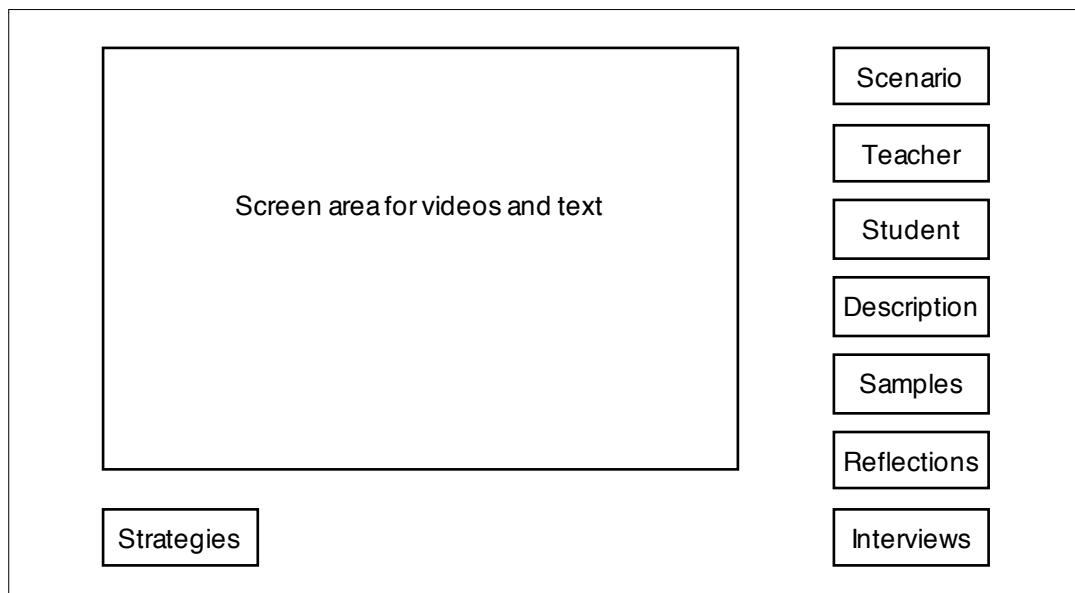
Figure 4.1:   Button-based interface design (rejected)

Jones, Farquhar and Surry (1995) suggest that metaphors help users to define the information in a program 'by relating it to a known function or process taken from an area or discipline familiar to the user' (p. 14). Hedberg and Harper (1992) also point out that metaphors aid the rapid interpretation of links to areas of the program, and help to limit misinterpretation. Such help was clearly lacking in the original button-based design, although it is feasible that students would have been able to navigate successfully, albeit not intuitively, through the program.

The final design for the interface used an ecological interface (cf., Pejtersen, 1993, sometimes known as pictorial or intuitive, or as a metaphor) rather than a button or hierarchical approach. Instead of clicking on words or buttons to move to parts of the program, students click on objects within the 'ecology' or environment of the interface,

a classroom. Students quickly learn where resources are located and can intuitively select the appropriate location in much the same way they access resources in a real classroom or office (Hedberg & Harper, 1996; Pejtersen, 1993). The interface simulates the front part of a classroom with the resources located in full view (see Figure 4.2). The student accesses each resource by clicking on the appropriate part of the picture.

A description and discussion of the strategy appear in text form when the top drawer is

The list of assessment strategies appear on the whiteboard

The video clips appear on the television screen

Scanned images of samples of children's work

Video clip of the assessment strategy in the classroom

A pre-service teacher's comments on the strategy

The teacher's comment

An interview with a mathematics education expert on the strategy

A student's comment

Students electronic notebook, which includes space for reflections and pastes from other documents, investigations and problems

Balloon help on the functions of the objects on the interface

Figure 4.2: Main interface of the assessment strategies program

The main interface acts as a main menu, and students can return to it at any time. Five other screens were required for the electronic notebook and the drawers of the filing cabinet. Each was designed to have a different look to help students distinguish the nature of the document currently on the screen, and also to assist in having a sense of location in the program, that is, knowing where you are at any given time. These designs are shown in Figures 4.5–4.9 below where the media elements are described in more detail.

Design requirements and professional standards of the graphic artist

The requirements of the main interface design were determined quite precisely to mesh closely with the situated learning framework and the media elements that were available to the students. However, the instructional design requirements of the interface were at odds with the professional standards of the computer graphic artist. The requirements of the interface were specified in consultation with the computer graphic artist. However, the first draft of the design incorporated a number of elements which were not present in the original sketches. For example, the artist had included items such as a dinosaur skeleton sitting on top of the filing cabinet, and a large ink blotter, desk drawer, lamp and a coffee mug on the desk (see Figure 4.3).
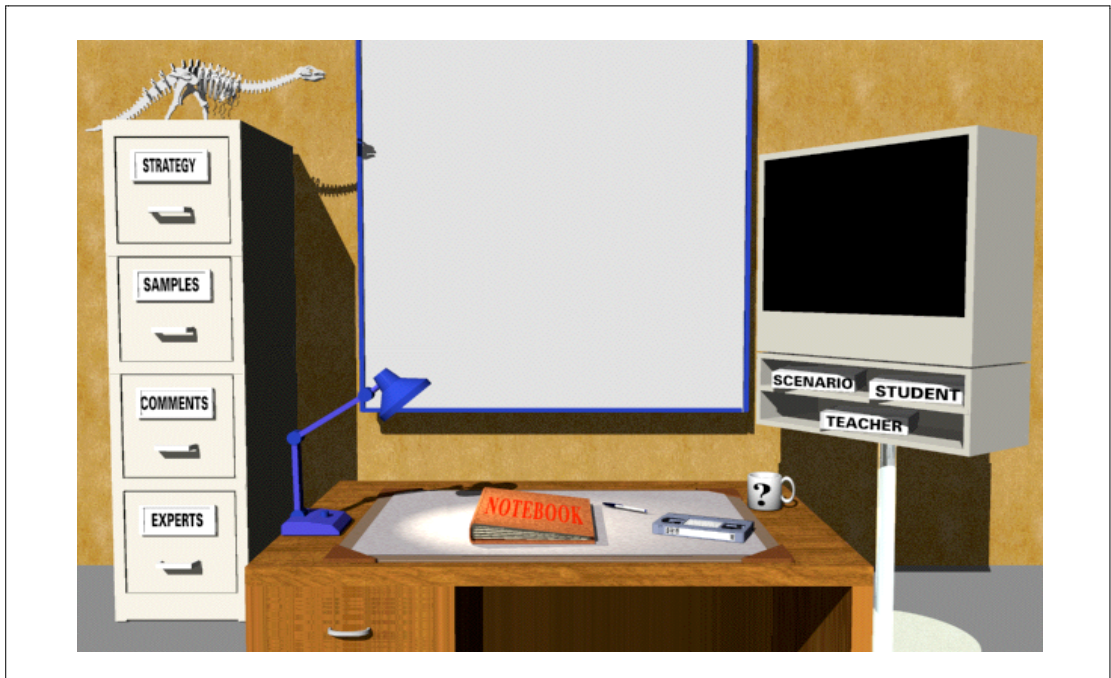
Figure 4.3:   First draft of interface

Apart from the fact that this reduced the requested contemporary look of the setting, it became an individual office in appearance, rather than the front section of a modern classroom. The artist's reasoning was that each of the items served to lead the eye around the screen from one element to another, starting from the top left hand part of the screen. and this was a justifiable design from his own professional perspective. However, from the point of view of the student using the program, this would mean that the student would start accessing the program from the top drawer of the filing cabinet, moving down the drawers, to the electronic notebook and finally the video clips. Such a step-by-step, ordered viewing of elements would be counter to the envisaged use of the program, where students consciously and thoughtfully access whichever parts of the program might help to answer their questions.

The inclusion of extraneous items in an ecological interface also confuses the user, at least initially, with potentially 'clickable' items which do not lead to any other part of the program. For example, if the user clicks on a filing cabinet drawer, it opens; if the user clicks on the desk drawer, nothing happens. Such inconsistencies were felt to be inappropriate and were consequently removed, resulting in a much starker, possibly less attractive, but more conceptually faithful, interface.

Production of program elements

The following sections describe the design considerations and production of the various components of the interactive multimedia program on assessment. Each section begins with a description and picture of the media element in the program together with descriptions of the decisions that were made with regard to each element's representation on the screen. This is followed by a discussion of the means used to obtain the resources, together with instructional design issues, problems and solutions. Table 4.1 below shows a complete set of elements for one of the assessment strategies, *Reflective prompts.* In the following sections, the design of these elements is described.

Table 4.1:   Progress record for Reflective prompts

Assess-ment Type	Tech-nique	Item No.	Scene	Yr	Samples	Video scen-ario	Video teach-er	Video stud-ent	Inter-view	Reflect-ions	Descrip-tion	Given to Prog
Self - Assessme nt	Reflective prompts	22	Teacher directing class to fill in lesson check	7	Copies of students' lesson checks	✔	✔	✔	David Clarke	✔	✔	10/1/96

A student using the program would first select a strategy to investigate from the complete list on the whiteboard, to gain access to all the media elements for that strategy.

Video scenes and interviews

By clicking on the video cassette objects under the television screen, students would be able to view a short video sequence of either the scene in the classroom where the teacher demonstrates the use of the technique (*Scenario*), the teacher's comments on the use of the technique (*Teacher*), or a student's comment (*Student*) (see Figure 4.4).

Figure 4.4: Main interface with student comment video playing on the television

Because of the large memory requirement and large number of the video segments, the image size of the television had to be kept very small in relation to the size of the computer screen. However, the use of the television image provided a very realistic frame for the videos which is much more true to life than having the small images 'floating' in space with the classroom in the background. Similarly, the choice of three videos on the shelves under the television provided a realistic way to choose a video segment. The controls under the television image would enable the students to control the progress of the video clip, allowing them to use the sliding switch to move the scene

along or to replay phrases or sections of the scene. They could also rewind, fast forward and pause the video, and control the volume of the audio.

Production of video scenes

In order to produce the short video *scenarios* of classroom scenes, and teachers' and children's interviews, the assessment techniques were first classified into types, and possible scenes were suggested as a starting point for discussion with the teachers who were to teach the segments.

The State Education Department was approached and 10 experienced teachers suitable for the teaching sequences in the program were recommended. All were invited to attend a meeting where the project aims and methods were explained, and their views sought. Six teachers attended the meeting and all were very eager to participate. Many had suggestions on additional assessment strategies and alternative ways of approaching the suggested scenes. At the end of the meeting, teachers were asked to nominate grade levels and areas of expertise that they would be happy to teach, and a suitable mix of K-12 was evident. Other teachers were approached as filming progressed to ensure a sufficient number of scenarios and an equitable mix of gender, and a total of 11 teachers were featured in the final program, all genuine teachers teaching their regular classes.

The Principal of each school concerned was approached by the content experts in the first instance for permission, and each was assured that disruption would be minimised and care taken not to interfere with school programs. Parents' or guardians' permission was needed in order to film students in the schools, so a permission slip was sent to all students' parents via the classroom teacher, prior to commencing filming. Teachers, and some parents who featured in the scenes, were also required to sign an agreement to allow use of their image on the video.

Recording the classroom scenes

A video producer was consulted to assist with the filming of video segments, together with a sound recordist. They were required to film up to 25 sets of scenarios consisting of video clips of the classroom sequence, and interviews with the teacher and the children. Given the shortness of the school afternoon, they were employed only in the mornings to record the scenarios. Filming of segments and tapes of interviews were scheduled for three separate blocks of time during the year. Sixteen mornings were scheduled in ten different schools to videotape the central video scenes of the assessment types in the classroom. The video sequences were filmed in the teacher's

normal classroom. The filming of the teachers' and children's comments also needed to be taped immediately after the classroom scene so that their thoughts on the task were fresh in their minds.

The video equipment used to record the sequences was minimal, consisting of a Panasonic broadcast camera, a tripod, three 800 watt focusable floodlights, and an ME80 portable microphone with windshield. The crew consisted of two people: the video producer and a sound recordist, although assistance was also given by members of the development team, who attended all the filming sessions.

Typically, in each classroom, the procedure was as follows. The teacher was asked to use or organise the assessment technique as he or she normally would, with children responding in the normal, spontaneous way. The scenarios in the classroom were filmed first followed by children's and teachers' comments, in response to questions from the content experts. The shots were later edited into a complete sequence.

Records were kept of the progress of each shot on a special sheet (see Appendix 2). This sheet also served as a reminder to collect samples of work and permission slips for children's participation.

Editing of video sequences
Video sequences were edited progressively at the conclusion of each filming session to reduce the footage shot to 1 to 2 minutes each. This was rarely longer than the real-time length of the assessment technique demonstrated, but the editing was necessary to incorporate the various perspectives and angles from the different shoots. Each strategy usually had a set of three video clips: the scene in the classroom, the student's comment and the teacher's comment. These were assembled onto the master tape ready to be digitised for the program.

Instructional design requirements and professional standards of the video producer
As with the computer graphic artist, there were some tensions between the instructional design requirements and the professional standards of the video producer. It was important from an instructional design perspective to ensure that the video segments were as realistic as possible, to enable students to observe peripherally the authentic procedures and culture of the classroom. This proved to be an almost impossible task.

As the footage was shot with a single camera, a single run through of a scene without knowledge of what was to occur, would need to be a very wide shot encompassing action from any area of the classroom. The film producer was not happy to

compromise his professional standards by producing footage which was composed almost totally of basic, static shots of large areas of classrooms. While a static picture was not an urgent problem from a design perspective, it was important to have pictures which were meaningful and able to be used in the manner intended. Given the reduced size of the finished picture on the classroom interface and the reduced quality of the digitised image, the larger the relevant characters in each scene, the better. A whole classroom scene displayed on the tiny television in the interface would mean that it would be virtually impossible to detect who was speaking.

The sound quality was also extremely important and was perhaps the deciding factor in the decision to edit the footage from the classrooms rather than shoot a single scene without interruption, as it occurred. A microphone was essential to pick up clearly what was being said, and this was unworkable without prior knowledge of who was going to speak.

A compromise situation was reached which entailed the content expert and the classroom teacher deciding on an assessment strategy and how it might be taught. The teacher then used the strategy in the most authentic way possible under the circumstances and the pattern of events was observed. The sequence was then re-enacted for the camera and filmed in its entirety, for example, with the camera focused on a fairly close shot of the teacher. This shot was then supplemented with cutaway shots of children responding, working in pairs, close-up shots of the children's work or the blackboard and so on. Notes were made on the progress sheet of most critical aspects to incorporate in the final edited sequence.

This compromise proved to work quite well and was as close as possible to the actual events that occurred in the classroom. Mistakes were deliberately incorporated where they had occurred and children were reminded occasionally to repeat the performance in a manner more closely resembling their original behaviour. However, there was inevitably a more assured and less life-like performance for the camera. For example, in filming the strategy on higher-order questions, when children were asked the question for the first time before the cameras were filming, there was a real spontaneity in their responses. They looked puzzled, or called out answers; some answered tentatively, others disagreed. When the sequence was repeated for the camera, the question was asked and one or two children's hands went up, with a rehearsed answer given. Nevertheless, the edited footage remained faithful to the original action and deliberately incorporated life-like errors and uncertainties, which the video producer would almost certainly have edited out without explicit instructions to the contrary.

Interventions in the classroom practice

In order to make the scenes in the classroom as authentic as possible, no interventions were made in the way the teacher taught the class. Apart from discussing possible approaches in advance of filming, no suggestions were made on how to approach the scene or how to handle the students. For example, the teachers were never asked to question boys and girls equally in the questioning sections. It was important to ensure that the teachers were free to perform in their normal manner, even if at times this was not the ideal. However, in selecting the children to be interviewed a more egalitarian approach was possible. Equal numbers of boys and girls were interviewed, and an appropriate variety of ethnic backgrounds were featured, together with physically and intellectually disabled children. The classes used in the filming featured a rich variety of cultural diversity, and this is a strong feature of the video footage.

The children's and teachers' interviews

A variety of methods were used to obtain a useful comment from the child interviewed. At first, a child was chosen almost randomly, but this often resulted in minimum useable footage. For example, when asked why he or she liked a particular type of assessment, the child might answer with just two words: 'It's fun'. Because of the importance of authenticity, none of these comments were reshot unless a child stumbled or made a mistake, so another approach was tried. A child was selected to be interviewed and then the whole class was asked the question and possible answers invited. While still answering in his or her own words, this technique gave the nervous interviewee a source of ideas from which to draw, and resulted in much more useful and insightful comment.

The teachers were also interviewed with very little advance warning and this generally resulted in natural and thoughtful responses. If the teacher was given time to consider the question, this was sometimes counter-productive and resulted in nervousness, writing answers down on paper and lack of spontaneity. Occasionally, the teacher gave strong opinions which were contrary to the ideas taught by the content experts in their classes, but these were not changed or reshot for the purpose of a consistent message. Such ideas serve to provide an alternative perspective for users of the program to consider.As well as the video resources available, each of the filing cabinet drawers contains a written resource which students could examine. These are described in detail in the sections below.

Written descriptions of assessment strategies

Clicking on the top filing cabinet drawer gave access to a description of the assessment strategy which includes advice on how to implement the strategy effectively in the classroom (see Figure 4.5). The style of the presentation simulates a book or journal where students are most likely to access this kind of information in real life. There are three buttons at the bottom of this screen which students could use either to return to the main interface after reading the information, to copy sentences or paragraphs or to move to the notebook.
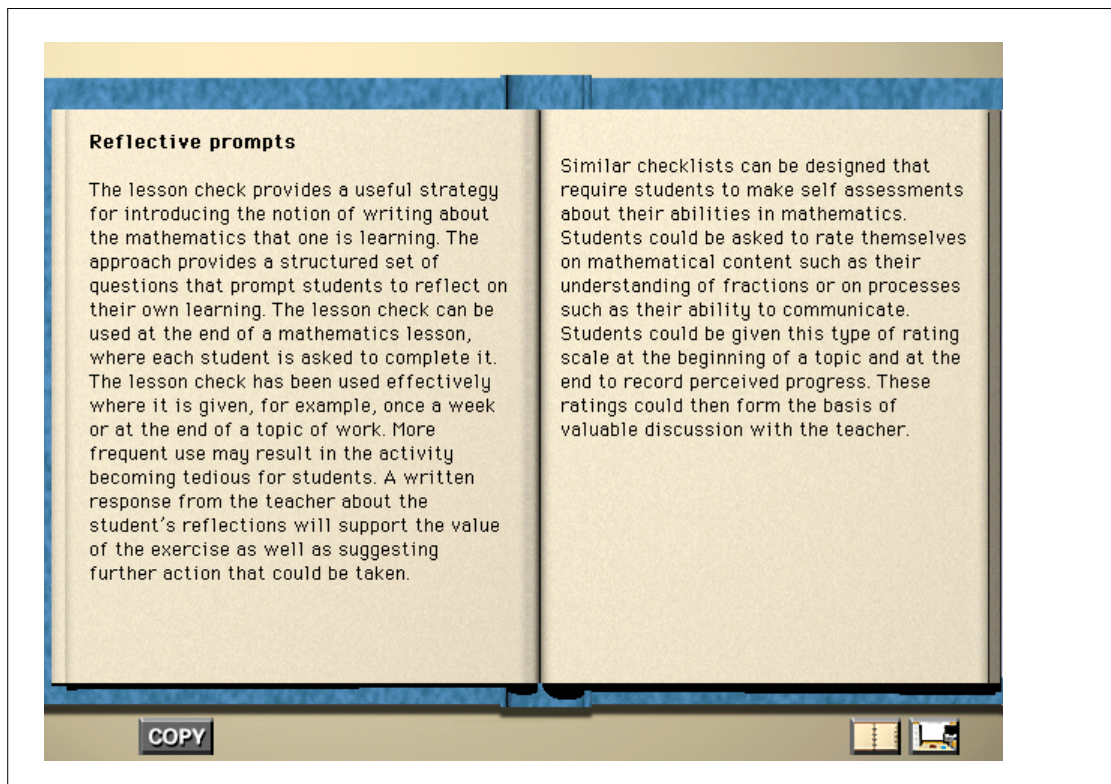
Figure 4.5:   Description of the assessment category (First drawer of filing cabinet)

Production of the descriptions

The written descriptions of the assessment strategies were short 200-300 word essays describing each strategy and its use in mathematics assessment. These essays were written by the content experts and were based on current literature and international guidelines on assessment, such as those produced by the National Council of Teachers of Mathematics (NCTM, 1995), the Cockcroft Report (DES, 1982) and the Mathematics Curriculum and Teaching Project (Curriculum Corporation, 1988). The essays were saved as document files and imported into the program.

Children's and teachers' work samples

By clicking on the second drawer students can examine samples of school children's work or teachers' records. These samples were collected from the schools at the time of filming the segments and then scanned and imported into the program. For example, Figure 4.6 shows a child's response to using the reflective tool, the *Lesson Check.* These items were generally scanned without alteration as they had been done by the children. The only editing was the removal of identifying data such as family names and names of schools.
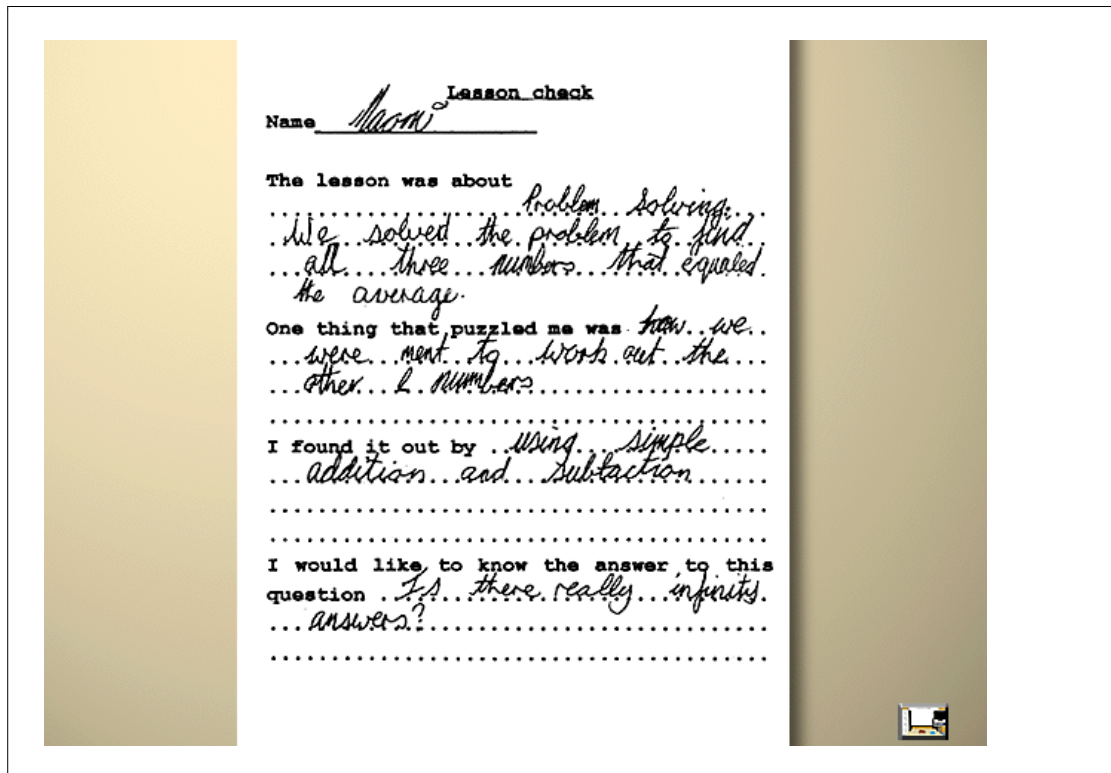
Figure 4.6:   Work samples of the assessment category (Second drawer of filing cabinet)

Production of samples

The children's and teachers' work samples were collected at the time of filming the video classroom scenes. If the teacher had set a written task for the class, and these featured in the video, the work was collected and later scanned for inclusion in the program. For example, in the strategy entitled *Open-ended* the teacher set the problem: 'The average of three numbers is 11.2. One number is 7.6. What are the other two?' In this case, a student's working out and solution to the problem has been included to enable preservice teachers to examine the process.

When appropriate, the teacher's work was included as the resource. For example, in the scenario on *Checklists*, the children are set a task, but the focus of the strategy is the teacher's notes on the checklist about the children's activity and performance, rather than the activity itself. In this case, the filled in checklist has been collected and included in the program.

Occasionally, it was not appropriate to include any work samples. For example, in the scenario entitled *Self-questioning*, the scene shows the teacher and children working through the Learning Check, a list of questions and prompts to encourage reflective self-questioning in problem solving. In this case, a copy of the Learning Check itself was included as a resource.

All the scanned resources in this section of the program allow preservice teachers to examine the actual documents which were used, or shown briefly, in the video scenes, and as such allow a more thorough scrutiny of relevant material.

Reflections

The third drawer of the filing cabinet was designed to provide thoughts and advice given by a preservice teacher, on his or her experience of using the strategy on professional practice in schools. The design of this screen simulates a ring binder to reflect the kind of location one would normally find a document produced by a tertiary student. The example given in Figure 4.7 shows the comments of a third year preservice teacher.

Reflective prompts
Reflections of a student teacher

At the end of each unit of work students were given a piece of paper and asked to write their name on top. They were then asked to answer the following questions as honestly as possible (answers must be justified):

• What did you enjoy about this unit?

• What did you find easy or difficult?

• What elements would you like to explore further?

• What work would you like more help with?

The questions are flexible and adapt to the unit. The answers give you an honest appraisal of the unit and where the children are at in terms of remediation and extension

(Debbie, student teacher)

COPY

Figure 4.7:   Preservice teacher's advice on the assessment category (Third drawer of filing cabinet)

Production of the preservice teachers' reflections and advice

The reflections and advice were obtained from preservice teachers in the last year of their undergraduate course, studying units taught by the two content experts. These students had completed a 10 week term of professional practice in schools. They were asked to give advice on using a particular strategy from their own experience on professional practice in schools. Generally, a list of questions was put to the students, such as: 'In your experience, what advice would you give to teachers wishing to use this strategy?' The preservice teachers replied by writing 200-300 words on their experience of using a particular strategy of their choice, the recommended context of its use together with hints on how to use it effectively.

Responses were edited, but only to correct spelling mistakes, repetitions and major grammatical errors. It was important to retain the terminology and idiom of a young person, only slightly more experienced and knowledgeable than the intended users of the program. An important consideration in the design of the program was that learners have the opportunity to observe not only accomplished teachers and experts but also other learners with varying degrees of skill (Collins, et al., 1989).

Interviews

Clicking on the bottom drawer of the filing cabinet gives students access to an expert commentary on the use of the assessment strategy (see Figure 4.8). The design of the interface simulates a features page of a newspaper to emphasise the fact that the document is based on an interview with the expert, rather than a scholarly piece of writing.

Apart from providing valuable advice on methods of implementing the strategies in the classroom, the expert's comment is important because it allow students to compare their own level of thinking on the issue with the expert's. This is critical to the kind of reflection students might engage in as they use the program.
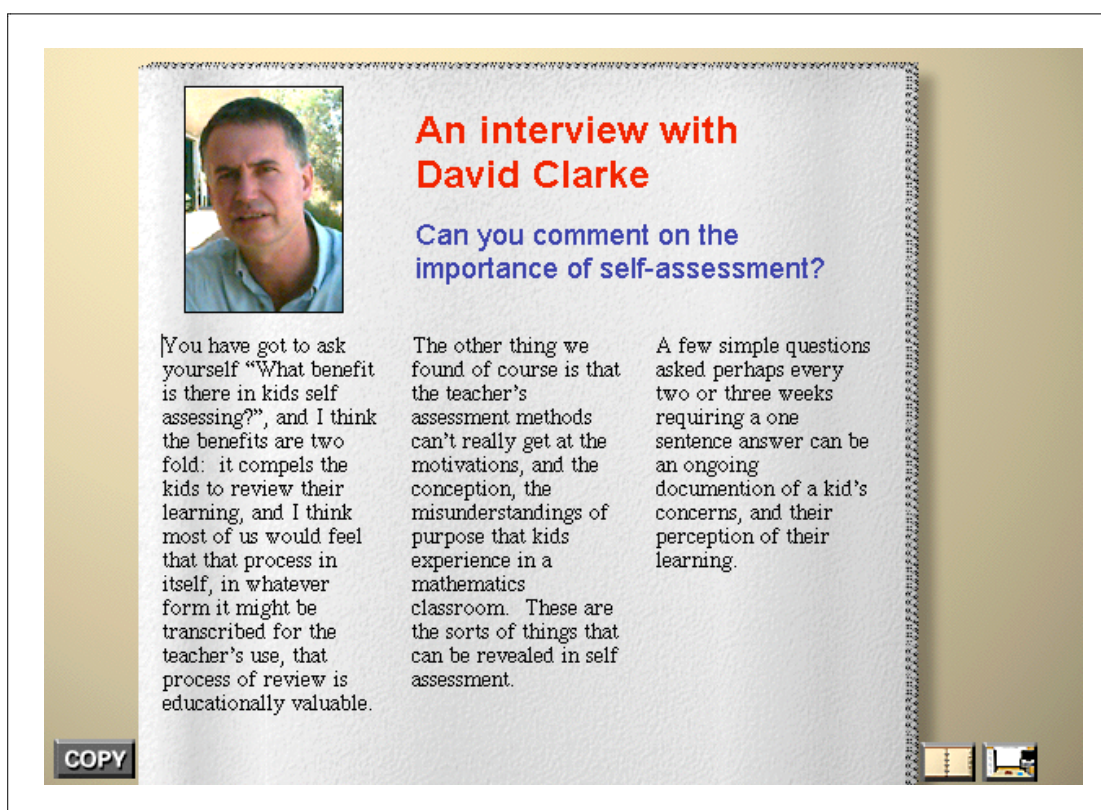
Figure 4.8: Expert comment (Fourth drawer of filing cabinet)

Production of expert comment interviews

The expert comments were generally acquired by interview by a variety of means. The content experts tape-recorded interviews with a number of eminent mathematics educators at an international conference on mathematics education at the time of the program development. Further expert comments were requested by email from

international contacts of the content experts and the visiting scholars. All the Professors of Mathematics Education in Australia were approached for expert comment and all but one contributed. Other comments were obtained by interviewing mathematics educators from various institutions with known interest and expertise in particular areas.

All the interviews were transcribed. Comments were edited for consistency and grammatical errors. The recorded interviews were made less colloquial in their transcription, and when changes were made they were returned to the experts for final checking.

Electronic notebook

Clicking on the notebook on the table allows students to use the electronic notepad (Figure 4.9) and also gives them access to the authentic activities of the program.

The first tab, the *Notes*, enables students to write their own reflections and ideas as they explore the various elements provided (as in *Investigating Lake Iluka*, 1993), and also to cut and paste text from three of the resources provided in the filing cabinet drawers: the description of the strategy, the preservice teachers' advice, and the expert's comment. In addition to the navigation icon enabling students to return to the main classroom interface, two additional buttons were included at the base of the notebook: a *Paste* and a *Save* icon. Clicking on the *Paste* icon enables students to paste copied selections into their notebooks. The *Save* icon is used at the end of a work session to save copies of students' notes to their own disks, where they can format them using their regular word-processing program.
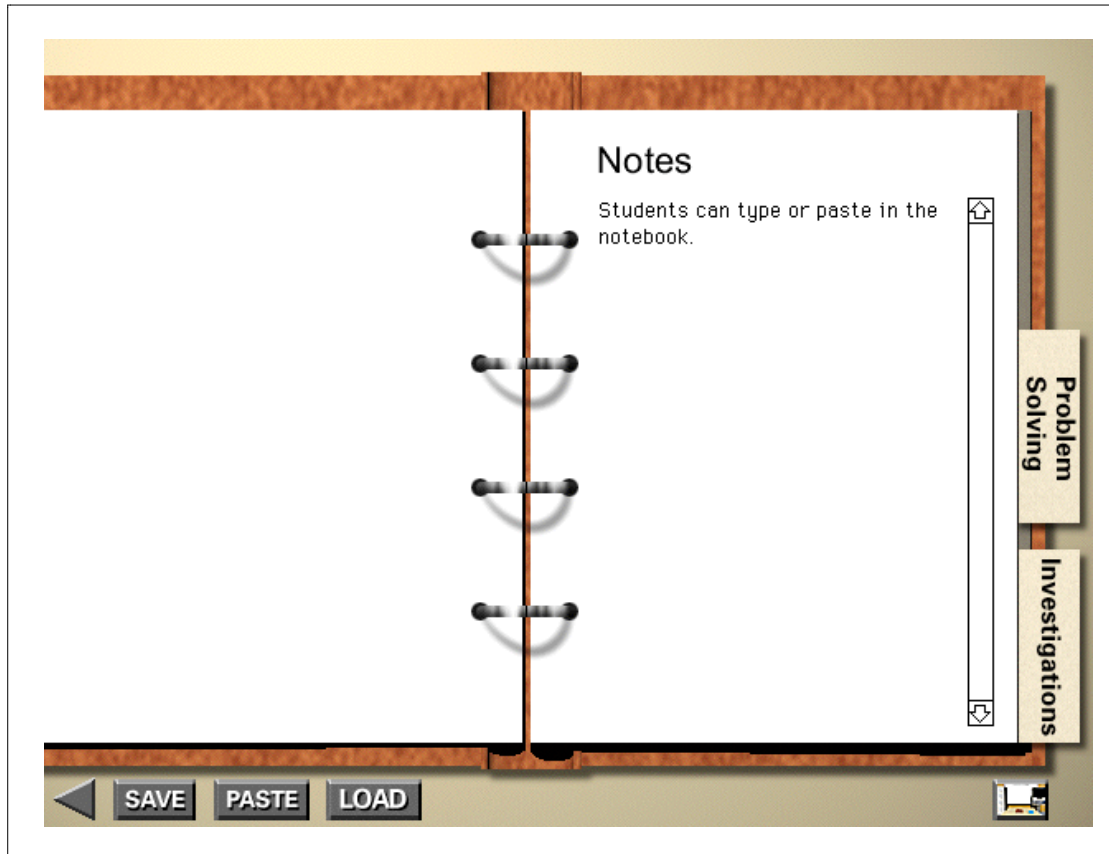
Figure 4.9:   Students' electronic notebook

The notebook had two essentially different functions. Firstly, it was important to provide a work space for students to use as the central organising zone for their thoughts and observations which was accessible from any point in the program. This facility was designed to enable students to record their thoughts and impressions as they progress through the program, and to copy relevant sections from any of the documents as appropriate. While there is always the danger that providing such a facility would enable students to copy large passages of material without understanding, described by McCalman (1995, p. 28) as 'learning by appropriation', it can serve to usefully support students in accommodating new information into their existing knowledge structures (Hedberg, Harper, Wright, & Farr, 1996).

The second purpose for the notebook was to provide problems and investigations for students to complete as they used the program. Clicking on the *Problem Solving* tab gives students access to short problems which are more narrowly focused and require less time to solve (see Figure 4.10).

Problem Solving

1. Make a list of different items that could be included in a student's mathematics portfolio. Explain how and why you would use a portfolio for assessment purposes.

2. In what ways can interviews be used to assess students' mathematical abilities?

3. Solve this problem:
A square has 2 diagonals. How many diagonals does an octagon have?
Indicate what you might assess from a student's written response to the problem.

4. List 10 questions that students may pose related to this statement:
The diagonals of a square are perpendicular

5. Change these closed questions to open-ended questions:
(a) 17 + 25 = ...
(b) Find the perimeter of a rectangle length 24 cm and width 15 cm.
(c) Factorise 2x − 6

6. Design a checklist that a teacher may use for this performance-based test question:
Using the newspaper make some shapes that have an area of 1 square metre.

7. Complete this modelling problem then develop a marking scheme.
How much paper will I use in school this year?

8. Indicate how you might implement journal writing in a mathematics classroom and how this may assist you in assessing students.

9. Outline ways that students could use to assess their own learning of mathematics and indicate how the activities may also provide assessment information for the teacher.

10. As part of your assessment of students you will be using a pencil and paper test. Choose a topic and develop a 40 minute test. Provide answers, a marking key and a brief written justification for your method of allocating marks.

COPY

Notes

Investigations

Figure 4.10:   The Problem Solving section of the notebook

Such problems do not necessarily conform to the situated learning model proposed for the program, but were included to allow lecturers a broader range of approaches and to add versatility to the resource as a marketable item. It means that lecturers are not excluded from using the package with their students if they cannot commit a large proportion of their course time to the topic. The problems could be attempted in a single work session rather than the extended period of time recommended for the investigations. The *Problem Solving* section was included as a commercial consideration, and to add versatility to the program; however, none of its features were used in the current study.

The last tab on the notebook, *Investigations*, takes students to a series of authentic activities which replicate the kind of task a school teacher might be faced with in real life. A sub-menu lists the five investigations, which students choose simply by clicking on the name of the investigation (Figure 4.11).
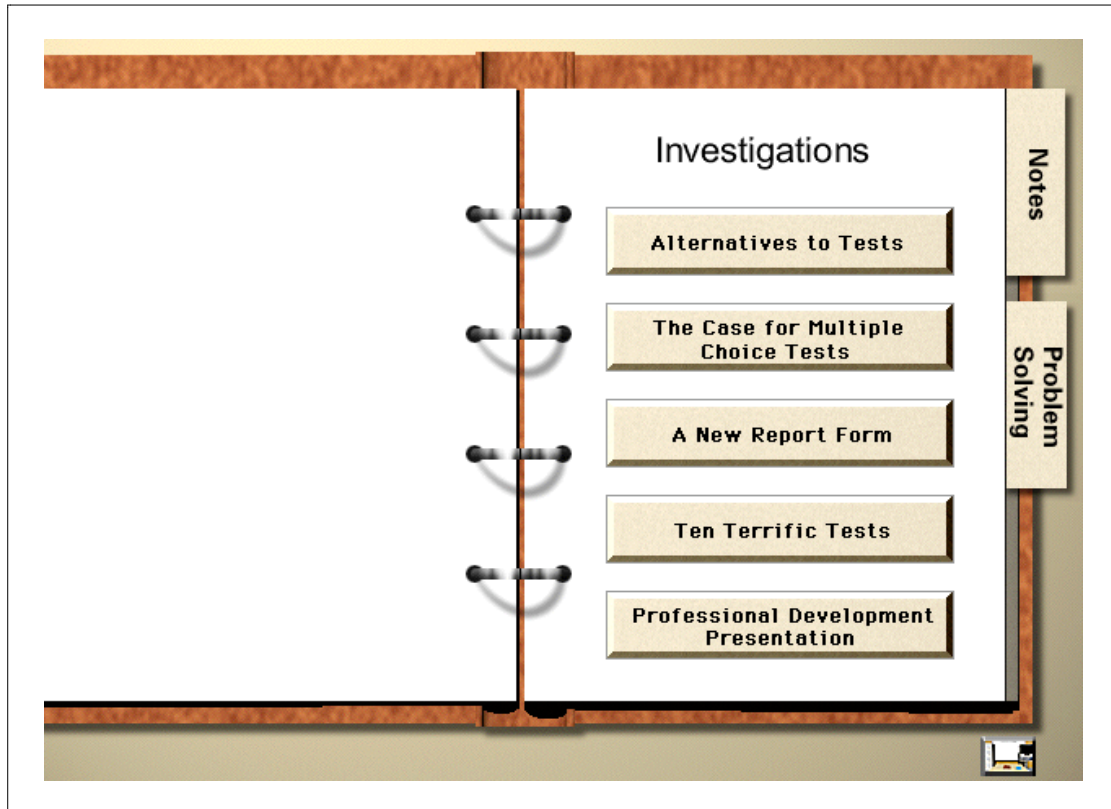
Figure 4.11:   Choices of investigations

The primary purpose of these activities is to provide the spark of interest that prompts
the students' curiosity about the issues (Ormell, 1996). The tasks are presented to the
student realistically, such as in a memo or letter, rather than simply a list of possible
activities, and they include genuine constraints such as deadlines and time allowances.
Activities assume that students will be working in pairs or small groups, and require
them to examine the resource from a variety of perspectives (see Figure 4.12 for an
example of an activity).

Collaborative learning

All activities are addressed to a group rather than an individual to allow for collaborative learning

Multiple perspectives

A problem situation is described which requires investigation of the resource from a variety of perspectives

Authentic task

A realistic task is set, requiring a written response

Articulation

An opportunity to articulate and defend findings is given, together with a recommended time limit

Memo to: New teachers

From: Rebecca Edwards, Mathematics Coordinator

Reference: Mathematics assessment

As discussed at our last staff meeting, there is considerable concern that mathematics teachers in our school are not using an appropriate range of assessment strategies in their day to day assessment of students. There have been several complaints from parents about the over reliance on pencil and paper mathematics tests, and the amount of anxiety this produces in their children.

As you are the most recent teachers to join our staff, and you have recently graduated from teacher training, it is felt that you are the most appropriate staff members to provide some guidelines on how we might proceed. I am writing to formally request that you prepare a report on alternative approaches to assessment in mathematics to be presented to staff.

I have allowed for your classes to be covered for a total of six hours over a period of two weeks. In that time, I would like you to observe other types of assessment being used in classrooms, and to talk to teachers, students, preservice teachers and experts about the techniques. Prepare a suggested plan on how our school might proceed, including benefits and problems for parents, students, and teachers.

I would be grateful if you could present your report at the next staff meeting, scheduled in three weeks. I will allow approximately 15-20 minutes for your report.

Thank you for your assistance in this matter.
Rebecca Edwards
Mathematics Coordinator

To the Principal

I am writing to express my concern at the number of maths tests Lauren is required to take. She gets extremely anxious before each of these tests, almost to the point of making herself sick. Is there any other way she could be assessed, as the constant tension is making our home life very difficult?

Yours Sincerely,

Authentic context

A supplementary document is provided, often the source of the problem that requires action

Figure 4.12:   Critical features of the investigations

The investigations can be assigned to students by the lecturer to ensure an appropriate representation of topics, or students can choose their own topics. It is important to remember that the resource also provides the opportunity for students to design their own investigations. The Cognition and Technology Group at Vanderbilt (1990a) suspect that student generation of tasks is beneficial for transfer to other activities, but they concede that the studies have yet to be done.

Additional resources

The previous sections described a complete set of elements on a single strategy presented in the assessment program. The program contains 23 of these complete sets. In addition, other components have been designed to assist users and facilitators, such as a *Help* facility, and these relate to the whole package, not to individual strategies. These additional elements, the *Help* section and the *Manual for facilitators* are described below.

Help section

The book on the desk with a question mark on its cover in the interface takes students to the help section of the package. When students click on the book, the cursor becomes a question mark. Students can drag the cursor over any item and a 'balloon' help note appears. For example, Figure 4.13 shows the help given when the cursor is dragged over the whiteboard area.
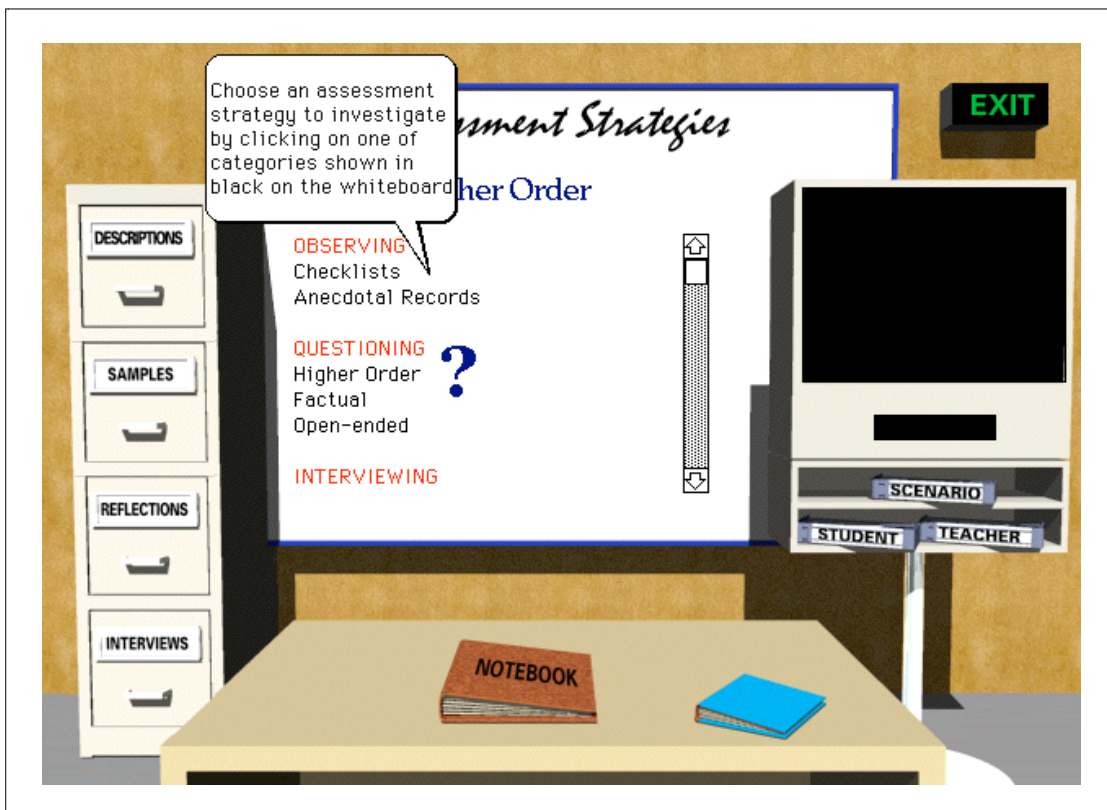
Figure 4.13:   Help section

The help disappears when the help book on the desk is clicked again, or when any other element, such as a filing cabinet drawer, is accessed.

Manual for facilitators

Some of the characteristics of the situated learning framework cannot be incorporated into the interactive multimedia program itself (see Figure 3.1). Elements such as coaching and scaffolding (which, to date, has been rarely incorporated effectively), might be provided by the lecturer, and elements such as articulation, by the learner. For the purpose of the research, advice on these aspects of the learning environment were discussed at length with the lecturer in the study. However, because the package is a learning resource in its own right, and because it will be used by lecturers and students independently of the research, it was important to explain the guidelines in the instruction manual which accompanies the resource.

The intention was not to produce an instructor's manual which gave step-by-step instructions on how to use the resource. The flexible nature of the interactive multimedia program and its role in the classroom experience eliminated such an approach. The learning promoted by the interactive multimedia program was not the kind that could be packaged and used as a self-contained finished product; it needed to be 'reinvented from location to location' depending on the needs and interests of the learners (Brown & Campione, 1994). The approach adopted in the instruction manual was to focus not only on the navigation aspects, but also on the learning theory behind the development of the program, or as Lin et al. (1995) have expressed it, guidance based on 'deep principles of relevant content domains and pedagogy' (p. 58).

A manual was designed to provide facilitators and lecturers with details about the program and recommended implementation conditions. The manual is a spiral bound book of 48 pages which includes a fold-over flap to encase the CD-ROM. In addition to providing a summary page of each assessment strategy, it outlines the minimum configuration of computer equipment required to run the program, and details on each of the media elements in the program and how they can be accessed.

Early in the booklet, a picture of the interface with descriptions of the contents of the various sections is provided, together with quick start directions for users (see Figure 4.14). This page can be photocopied and given to students when they first begin to work with the program.

The elements in the program and how to access them
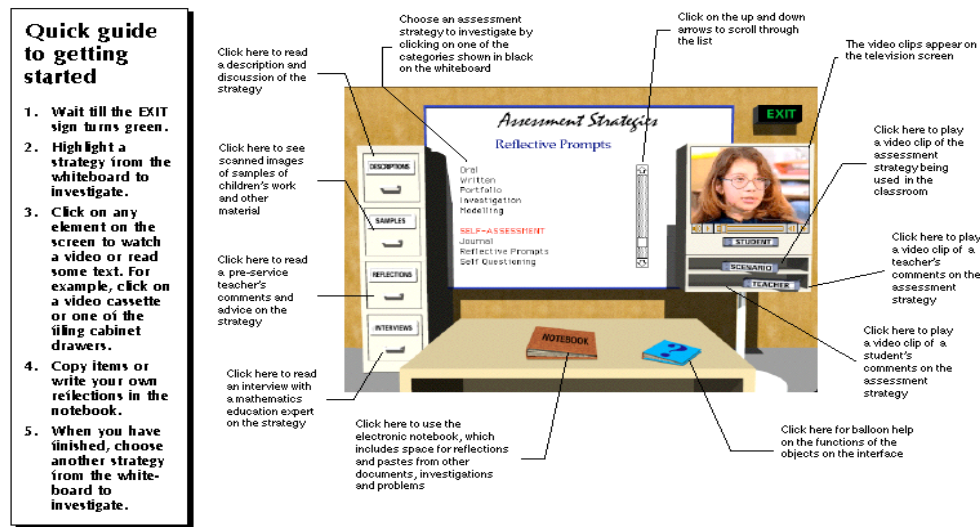
Figure 4.14:   Summary page of program functions and quick guide to getting started

The manual was designed to provide lecturers and students using the resource with some understanding of the theoretical framework on which the program was based and also to assist lecturers to use the resource in a way most likely to optimise students' learning. A list of optimum implementation conditions is provided in the book (Figure 4.15).

	Users will gain the most from the program if it is used under the following conditions:
Focus of investigation:	The resource is best examined in depth, from a number of different perspectives
Length of time:	Best used over a sustained period of 2-3 weeks rather than for a single session
Number of students:	Students working in pairs or small groups around each computer, rather than individually
Teacher support:	Teacher present during use to provide 'scaffolding' and support, rather than as an independent study activity
Setting the task:	Teacher demonstrates the resource by thinking-aloud as an investigation is modelled. Students then choose an investigation from those provided, or their own choice.

Figure 4.15:   Optimum conditions for use of interactive multimedia program on assessment

These conditions acknowledge the position that not all the critical elements of this model can be incorporated into the program itself. Some of necessity must be provided by the lecturer, and some by the students themselves.

The five investigations are also provided in the book to enable the lecturer to photocopy them and distribute to students as appropriate. Because the investigations are complex (each consists of two authentic-looking documents such as memos and letters), and the requirements are multi-dimensional, it is useful for students to have the task accessible while they are using other media elements. Having a 'hard' copy of the document in front of them, means that students do not need to move from the part of the program they are in to the notebook to check details of the task requirements.

Compiling the elements

The production of all the elements that comprise the total package took place on a number of different fronts, and in a variety of media. When all the components of a strategy were finished they were passed to the computer programmer who assembled the master version of the program.

The progress of the package was tracked on a matrix recording the status of each strategy and how close it was to completion (see Appendix 3 for a representation of the project approximately half way through development).

Formative evaluation of the project

As the assessment program was being developed, it was evaluated formatively in four ways: implementation and observation with a class of students, student consultation, peer review, and group discussion with student users. Information obtained through these methods was used to modify and refine the program throughout the development cycle.

Trial implementation and observation with a class of students

The program was evaluated shortly after it was first compiled in full. It was implemented with a class of students in the same conditions for which it was designed, that is, with students working on the program over 2-3 weeks, working in collaborative groups with their lecturer present. Students were observed using the program and asked to comment on screen design, navigational buttons and ease of use. They were also asked to note down on a large grid any problems or mistakes they encountered as they accessed the various elements of each strategy. Several minor mistakes, such as spelling mistakes, were corrected, as well as two or three major problems from a user's perspective, such as the fact that all the contents of the notebook were highlighted and

accidentally replaced with the new information that students attempted to paste. These problems are described in more detail in the following chapter.

Student consultation

Students from the target population—undergraduate teacher education students—were consulted in the early stages of development of the assessment strategies program. Second year secondary mathematics students were surveyed on their awareness of assessment strategies, and the context in which would they use them. The results of the survey were useful in determining the necessary scope of the program.

Students were also asked to evaluate the method of assessment at the conclusion of the unit of study in which the pilot program was used. They were asked to comment in writing on the two aspects of assessment: the written report and the oral presentation to the class. Several suggestions were made which related to the method of implementation, such as one suggestion that unequal group numbers were inequitable.

Group discussion with student users

At the conclusion of the trial implementation, the lecturer of the class conducted a whole group discussion on the assessment program. The discussion lasted approximately 20 minutes , and covered general issues such as the effectiveness of the program and its strengths and weaknesses, and more specific items such as each group's navigational strategies.

Peer review

Two visiting mathematics education lecturers provided invaluable advice and feedback on the program in the early and later stages of the development. Their involvement was described earlier in this chapter. The experts who were invited to contribute their thoughts for use in the program in the *Interviews* drawer, also provided considerable informal feedback on other media elements and the program as a whole.

Conference presentations and workshops were delivered on the program in two distinctly different academic domains: mathematics education and instructional technology. In both areas, the developing assessment program was open to criticism and review by academics and students throughout Australia. Substantial feedback and constructive criticism was achieved through this process. Peer review was also used extensively close to the end of development in providing quality control of the final

version. This entailed a number of academics systematically reviewing each strategy in the program with each version of the program as it was cut to CD-ROM.

The formative evaluation was conducted throughout the entire period of development of the assessment program, and many alterations and refinements were made on the basis of this information.

Critical characteristics: How they are covered

In developing the interactive multimedia on assessment it was important to ensure that the critical characteristics of the situated learning model were incorporated, where possible, into the design. This process was described in the discussion of the development of the program above, and a summary is provided in Table 4.2 below.

Table 4.2:   Manifestation of critical elements of situated learning in the learning environment

Element of situated learning	Guidelines for implementation	Manifestation in the learning environment
Provide authentic context that reflects the way the knowledge will be used in real-life	❏ a physical environment which reflects the way the knowledge will ultimately be used	❏ the classroom interface and program organisation around the central context of mathematics classrooms
	❏ a non-linear design to preserve the complexity of the real-life setting with 'rich situational affordances'	❏ non-linear navigation enabling ready access to any media element in a non-sequential order
	❏ a large number of resources to enable sustained examination from a number of different perspectives	❏ a large number of resources provided: 23 classroom scenes, 43 video interviews, over 60 text documents and 20 samples of work
	❏ an editorial policy which makes no attempt to fragment or simplify the environment	❏ no simplification of real-life resources

Element of situated learning	Guidelines for implementation	Manifestation in the learning environment
Provide authentic activities	❑ activities which have real-world relevance	❑ five investigations mirror the kind of tasks teachers face in real life
	❑ ill-defined activities	❑ the problem is presented in the form of two letters or memos, there is no well-defined task
	❑ a single complex task	❑ each investigation presents a complex task with a single sustained context
	❑ an opportunity for students to define the tasks and sub-tasks required to complete the activity	❑ when given the two documents for investigation, students determine a course of action
	❑ a sustained period of time for investigation	❑ including the presentations to class, students work on the project for weeks rather than days
	❑ the opportunity for the detection of relevant versus. irrelevant information	❑ no attempt made to edit out irrelevant material
	❑ the opportunity to collaborate	❑ each investigation is addressed to a group, and students are advised to work in collaborative groups
	❑ tasks which can be integrated across subject areas	❑ assessment strategies presented are relevant to other disciplines
Provide access to expert performances and the modelling of processes	❑ access to expert thinking and modelling processes	❑ experienced teachers model assessment strategies in the *Scenarios*, and experts give their perspectives in the *Interviews*
	❑ access to learners in various levels of expertise	❑ third year undergraduate preservice teachers give their advice in *Reflections*
	❑ opportunity for the sharing of narratives and stories	❑ collaborative groups enable the sharing of stories
	❑ access to the social periphery or the observation of real-life episodes as they occur	❑ scenes were filmed in real classrooms to provide real-life episodes
Provide multiple roles and perspectives	❑ different perspectives on the topics from various points of view	❑ each strategy can be seen from the perspective of the classroom teacher, a school student in the class, a mathematics education expert and a preservice teacher
	❑ the opportunity to express different points of view through collaboration	❑ collaborative groups and the presentations to class enable the expression of different points of view
	❑ the opportunity to criss-cross the learning environment by providing more than one investigation	❑ five investigations are provided, together with shorter problems and the option of students creating their own investigations

Element of situated learning	Guidelines for implementation	Manifestation in the learning environment
Support collaborative construction of knowledge	❏ tasks which are addressed to a group rather than an individual ❏ classroom organisation into pairs or small groups ❏ appropriate incentive structure for whole group achievement	❏ each investigation is addressed to a group, e.g., the Mathematics Sub-committee ❏ lecturers are advised to divide students into small collaborative groups ❏ grades for class presentations and written reports are given for a group effort, not individually
Promote reflection	❏ authentic context and task ❏ non linear navigation to enable students to return to any element of the program if desired, and to act upon reflection ❏ the opportunity for learners to compare themselves with experts ❏ the opportunity for learners to compare themselves with other learners in varying stages of accomplishment ❏ collaborative groupings of students to enable reflection with aware attention	❏ classroom context and task reflects a real-life role for a teacher ❏ non-linear navigation enabling ready access to any media element in a non-sequential order ❏ students can compare their thoughts to an experienced classroom teacher and mathematics education experts ❏ students can compare their thoughts to a preservice teacher in the third year of their teacher training course ❏ collaborative groups recommended
Promote articulation	❏ a complex task incorporating inherent, as opposed to constructed, opportunities to articulate ❏ groups to enable articulation ❏ public presentation of argument to enable articulation and defence of learning	❏ the complexity of the investigation affords a necessity to articulate to complete the task, rather than in response to cues built into the program ❏ collaborative groups recommended ❏ articulation and defence of findings in oral presentation to the class

Element of situated learning	Guidelines for implementation	Manifestation in the learning environment
Provide coaching and scaffolding	❏ a complex, open-ended learning environment	❏ classroom context and open-ended complex task with no simplification of procedures
	❏ a non-linear multimedia design which does not attempt to provide program scaffolding and coaching	❏ non-linear design with no program feedback
	❏ flexible suggestions and guidelines to address the needs of the lecturer who may wish to optimise the use of the program in a variety of different contexts	❏ suggestions on ways to implement the program in the classroom provided in the *Manual for facilitators*
	❏ collaborative learning, where more able partners can assist with scaffolding and coaching	❏ collaborative groups recommended
	❏ recommendations that the lecturer implementing the program is available for coaching and scaffolding assistance for a significant portion of the period of use	❏ suggestions provided in the *Manual for facilitators* on the scaffolding and coaching role and the recommend-ation that lecturers be available to students for a significant portion of the period of use
Provide for authentic assessment of learning within the tasks	❏ fidelity of context	❏ classroom context
	❏ the opportunity for students to be effective performers with acquired knowledge, and to craft polished, performances or products	❏ students are required to present a formal written report and a public presentation to class (details of organisation are presented in the *Manual for facilitators*)
	❏ significant student time and effort in collaboration with others	❏ complex investigation requires significant time (2-3 weeks recommended)
	❏ complex, ill structured challenges that require judgement, and a full array of tasks	❏ open-ended complex task with no simplification of procedures, requiring written and oral responses
	❏ the assessment to be seamlessly integrated with the activity	❏ students are assessed on the results of the investigation, there are no separate tests
	❏ multiple indicators of learning	❏ indicators of learning comprise a formal written report and an oral presentation
	❏ validity and reliability with appropriate criteria for scoring varied products	❏ assessment is based on results of investigation not formal tests; peer assessment is recommended for the presentations (criteria are provided in the *Manual for facilitators*)

Once the program had been designed and produced, and guidelines for implementation were determined, the study could be conducted using a resource which embodied the essential characteristics of a situated learning model. The methodology for the five parts of the research is discussed in the next chapter.

Methodology

Once the characteristics of the situated learning model had been determined (described in Chapter 3) and a suitable learning environment produced to embody the necessary characteristics of the model (described in Chapter 4), the study could be conducted.

This chapter begins with a literature review of the research methodology used in the study, with justification for its choice. The research was conducted in five parts, and the methodologies of the studies are described in detail. The chapter concludes with a discussion of the ethical considerations which needed to be made for the study to protect the rights of the participants, and a summary of the methods used to ensure reliability of measures and validity of the research.

Research methodology

In selecting a research methodology, Guba (1981) suggests that 'it is proper to select that paradigm whose assumptions are best met by the phenomenon being investigated' (p. 76). Similarly, Howe and Eisenhart (1990) contend that the methodology employed should be judged in terms of its success 'in investigating educational problems deemed important' (p. 2).

The debate about the relative merits of the quantitative and qualitative methods has been present in the literature for the past three decades or more. The extreme positions can be represented by Campbell and Stanley (1966) and Guba (1992). Campbell and Stanley (1966) were early ardent advocates for experimental methodology, a method they describe as 'the only means for settling disputes regarding educational practice, as the only way of verifying educational improvements, and as the only way of establishing a cumulative tradition in which improvements can be introduced without the fadish discard of old wisdom in favour of inferior novelties' (p. 2). Guba (1992) is at the other end of the continuum in suggesting that a radical paradigm shift towards qualitative research will rightfully replace and eradicate quantitative methods.

LeCompte and Preissle believe the qualitative-quantitative comparison of research designs is not productive. They argue that 'polarizing social science research into qualitative ... and quantitative ... is a parody unduly dichotomizing research designs' (LeCompte & Preissle, 1993, p. 46). Far from being mutually exclusive, qualitative and quantitative methodologies can add complementarity to the strength of the findings (Firestone, 1987). Even Campbell mellowed his approach in later years from his extreme position that the 'one-shot case study' was 'of almost no scientific value' (Campbell & Stanley, 1966, p. 6) to one where he concedes that if the results of qualitative and quantitative research conflict, the quantitative results should be mistrusted until the reasons for the discrepancy are understood (Campbell, 1979).

A popular research design in instructional technology is to compare the adoption of a new innovation with the same material taught in a traditional manner. The problem with this design is the difficulty in determining the mythical 'traditional' approach. The Cognition and Technology Group at Vanderbilt (1993a) discuss the inadequacy of this research design: 'If the 'traditional approach' that is provided is of especially poor quality, and if tests are more aligned with instruction in one's experimental group than one's control group, it is often less than illuminating to show that one group of students performed better than the control group' (p. 59). Several writers (e.g., Russell, 1997; Clark, 1989) are critical of the prevalence of this design: 'Such comparisons generally have produced useless information ... The outcome is well known in advance and nothing of importance is learned' (Clark, 1989, pp. 58-59).

House (1991) has also noted that 'specifying the treatment in an experimental design may be misleading because it may lead one to believe that the program is either necessary or sufficient for the outcome to occur when it is not ... a realistic conception of causation might see events as being produced by the interaction of a multitude of underlying causal entities operating at different levels' (p. 7). This position is supported by Salomon (1991) who suggests that research methodologies can be categorised as *analytic* or *systemic*. He argues that if you are researching a *system* of interrelated factors and events that it is impossible to isolate and study a single factor for the purposes of comparison: 'Each component, event or action has the potential of affecting the unit as a whole; the whole is assumed to be more than the sum of its parts' (p. 14).

In Salomon's terms, the research suggested in this study looks at a complex *system* of interrelated factors. There is compatibility in this research between the systemic nature of the subject matter and the use of qualitative research methods. The nature of the learning medium of interactive multimedia, with its high degree of learner control,

'meshes precisely with the naturalistic assumption of individual constructions of reality' (Neuman, 1989, p. 41). Similarly, the choice of naturalistic or qualitative research methods is compatible with the constructivist nature of the theoretical framework of situated learning used in this study.

Instructional technology and interpretive research

Ferretti (1993) notes that research into interactive multimedia is clearly in a formative state and calls for 'more sustained research attention' to the efficacy of multimedia. However, to date the majority of research in instructional technology has been conducted using quantitative research methods. Shank (1994) bemoans the fact that few educational psychologists have adopted qualitative methods and few major journals in the field have published qualitative research. Clark (1989), commenting on the fact that there has been a massive increase in the quantity of research in instructional technology since 1975, notes that more research does not necessarily mean better research.

Reeves (1995b) reviewed the research studies published in two journals which could be considered primary research journals in the field of instructional technology, *Educational Technology Research and Development* (ETR&D), and the *Journal of Computer-Based Instruction* (JCBI) over a period of 6 years. His classification scheme distinguishes between the goals and the methods of research. He proposes that the principal *goals* for most research done in the area of instructional technology can be grouped into six categories: theoretical, empirical, interpretivist, postmodern, developmental, and evaluation; and the research *methods* commonly used can be grouped into five categories: quantitative, qualitative, critical theory, literature review, and mixed-methods.

Reeves (1995b) criticises the prevalence of research which is 'empirical in intent and quantitative in method' (p. 7). He found 38% of the ETR&D articles and 43% of the JCBI articles fell into this category on a matrix of research goals and methods. The next largest group was classified as theoretical in intent using literature review as the method of research (29% in ETR&D and 13% in JCBI). By comparison, only 3% of the ETR&D articles and 1.5% of the JCBI articles fell into the interpretivist-qualitative cell of the matrix. The combined totals for each matrix are presented in Table 5.1.

Table 5.1: Classification of frequency of types of ETR&D and JCBI articles (Reeves, 1995)

	Quantitative	Qualitative	Critical Theory	Literature Review	Mixed-methods
Theoretical				48	
Empirical	95	3		2	9
Interpretivist		3			1
Postmodern					
Developmental		1		7	3
Evaluation	7	6		5	28

The prevalence of empirical, quantitative research suggests that the nature of instructional technology lends itself to that type of research. However, Reeves concludes that a deeper analysis of the empirical-quantitative articles in both journals reveals that much of this research is 'pseudoscience' and so flawed that 'it has little relevance for anyone other than the people who conduct and publish it' (Reeves, 1995b, p. 9). Reeves (1993c; 1995b) distinguishes nine characteristics of pseudoscience such as inadequate literature review, measurement error, inadequate sample sizes, and meaningless discussion of results. If these characteristics are examined in terms of the research articles examined by Reeves (1995), 72% of the ETR&D, and 61% of the JCBI articles exhibit two or more characteristics of pseudoscience.

Others studies, principally of quantitative research, by Hall, Ward and Cromer, and by Ward, Hall and Schramm (cited in Tuckman, 1990) report that 40% and 60% respectively of published work was judged by experts to be 'either badly in need of revision or totally unacceptable' (p. 22). Reeves urges researchers to press for a new 'socially relevant research agenda' (p. 10) where a halt is called to simply finding out how instructional technology affects learning, and a new emphasis is placed on making education work better: 'If we continue as before, mindlessly conducting pseudoscience, the obsolescence of our field per se is a likely outcome' (p. 13). Reeves (1993c) cautions against the wholesale replacement of quantitative methods of research with poorly conducted qualitative methods, stating that: 'interpretivist, qualitative inquiry must also be well-conceived and rigorously applied' (p. 44).

The research proposed in this thesis seeks to understand the nature of a purposely designed learning environment, and the manner in which students interact with it. The use of an interpretive, qualitative methodology is considered most suitable for this purpose, firstly, because of its compatibility with the subject and theoretical

framework, and secondly, because of the dearth of research of this nature in the field of instructional technology.

Ensuring no duplication of effort

Throughout the literature review given in Chapters 2 and 3, a large number of research studies have been described which have tested situated learning environments. It is important to ensure that the present research does not duplicate this previous research and offers a new perspective to the current knowledge on situated learning in multimedia learning environments. Table 5.2 provides a summary of three recent research studies, chosen as salient to the present study in order to compare the characteristics of each. The first column gives the essential features of the present study, the remaining columns compare the characteristics of the comparative studies. This process of comparison was done with all studies examined in the literature in order to ensure that no unnecessary duplication of effort was being made.

Table 5.2: Comparison of present research to other research work in the field

	Present research	Chee (1995)	Griffin (1995)	Bartasis & Palumba (1997)
Title of paper /thesis:	*Authentic learning in interactive multimedia environments*	*Cognitive apprentice-ship and its application to the teaching of Small-talk in a multimedia interactive learning environment*	*You can't get there from here: Situated learning, transfer and map skills*	*Teaching and learning information search strategies in a situated hypermedia environment*
Broad aim of research	To investigate whether situated learning provides a useful instructional design model for multimedia, whether students use higher-order thinking and whether learning transfers to practice	To critically review traditional approaches and present an overview of cognitive apprenticeship as an approach to leaning, applied to the learning of Smalltalk programming	To explore the comparative effective-ness of two instructional methods, one based on situated learning the other based on a traditional classroom-based presentation	To explore the role of instructional guidance to aid the development of search strategies in a commercially produced situated, hypermedia environment
Technology , media or technique examined	Multimedia Purpose designed software: *Investigating assessment strategies in mathematics classrooms*	Multimedia Purpose designed software: *SmallTalker*	Map reading skills	Hypermedia Commercial software: *The Nile: Passage to Egypt*
Methodolo gy	Interpretivist Qualitative	Evaluation study (descriptive)	Empirical Quantitative	Empirical Quantitative
Students	8 preservice teachers in 2nd year of course	Novice programmers	49 4th grade students	32 5th grade language arts students
Elements of situated learning	Authentic context Authentic activity Expert performance Multiple perspectives Collaboration Articulation Reflection Coaching & scaffolding Authentic assessment	Expert performance Coaching & scaffolding Articulation Reflection	Authentic context Expert performance Multiple perspectives Articulation Coaching & scaffolding (Collaboration allowed in traditional instruction group but not situated learning group)	Authentic context Expert performance Collaboration Coaching & scaffolding (Coaching and scaffolding provided for guided group)
Higher-order learning	Do students use higher-order thinking as they use the interactive multimedia program?	No	No	No
Transfer effect	Does learning transfer to teaching practice?	No	Hypothesised that situated learning group would perform better on a transfer perform-ance assessment	No

As these three comparative cases show, the design and methodology of the present research is different in both focus and scope. The model of situated learning presented here is also unique, drawn as it has been from the literature rather than a predetermined definition. Thus, it appears that no other study has examined the combination of situated learning elements, as presented by the model developed for this research study, and how these elements influence learning. Similarly, no other studies have sought to examine higher-order learning within a situated learning environment. Furthermore, the qualitative methods used by the present study mediate against replication of results (Schofield, 1990) in that even an identical study would yield potentially useful cumulative findings.

The research methodology for the current study was guided by the principles of interpretive inquiry outlined by researchers such as Eisner (1991), Miles and Huberman (1994), and LeCompte and Preissle (1993). The project was conducted in five parts.

Part A: Definition of critical characteristics of situated learning and development of framework

The critical characteristics of a situated learning model were ascertained from the research, debates and discussion generated in the literature (Chapter 2). A situated learning model for the design of an interactive multimedia program was then developed. This was discussed in detail in Chapter 3.

Part B: Design and production of interactive multimedia package

A complete instructional package was designed to incorporate the critical elements of a situated learning environment as determined in Part A of the research. An interactive multimedia program, and recommendations for its implementation, was developed in the area of assessment strategies for mathematics teachers of grades K-12. The development of the instructional package was described in Chapter 4.

Part C: Pilot study

A pilot study was conducted to determine the feasibility of the proposed research design, and to identify any problems with equipment and data collection methods. It was also undertaken to provide data to assist with the development of a classification

scheme to analyse the student interactions, with particular emphasis on cognitive processes and the relative influence of the critical characteristics defined in Part A.

The interactive multimedia program on assessment was introduced to a class of approximately 12 preservice secondary teachers studying mathematics education method. The students were midway through the first semester of the second year of their course.

The study was conducted with the researcher in the role of 'observer-as-participant' with a consequent diminished degree of involvement in the activities in the classroom. Gold (1969) identifies four different roles of an observer in qualitative research (see Figure 5.1). The researcher was identified to the group as a researcher, but no attempt was made to become part of the group.

Complete participant	Participant-as-observer	Observer-as-participant	Complete observer
➡	➡	➡	➡
Identity not known to group. Researcher interacts naturally with group as a member.	Participates fully with group, but identity as researcher known to group.	Identity of researcher known, but no attempt made to participate as a member of the group.	Researcher observes without any involvement in group activities.

Figure 5.1:   Roles of observer in qualitative research (after Gold, 1969)

The lecturer responsible for the class during the period of the pilot study was one of the content experts who contributed to the development of the interactive multimedia program on assessment. He was not the lecturer normally responsible for the class, but conducted the lessons over the two week period that the students used the package. The class was held in a computer laboratory which was arranged with computers around the perimeter of the room and a large table, suitable for whole-group discussion, in the middle.

To begin the lesson (a full lesson plan is included in Appendix 4) the lecturer held a discussion with the students on the issue of assessment in mathematics. The discussion was prompted with questions such as: What does assessment mean in mathematics? How were you assessed in mathematics when you were at school? The discussion ultimately came to the position that there are many acceptable and innovative alternatives to the traditional pencil-and-paper tests when it comes to assessing student performance in mathematics.

Students were then introduced to the interactive multimedia program. Minimal instruction was given in the use of the assessment program itself, except for a brief

introduction to the elements of the program and how each could be accessed through the main 'menu', the classroom interface. Students were also given a demonstration of the notebook facility and how it worked. The lecturer, who was thoroughly familiar with the program, modelled an investigation for students by suggesting a problem and then thinking aloud as he suggested how the resource could be used to answer the question.

Students were asked to work in small collaborative groups of 2-3 students. They were very practised at organising themselves into such groups and quickly set themselves up at the computers on which the assessment program was loaded. One of the planned investigations was distributed on paper to all students to investigate (as it appeared in Figure 4.12). The activity required the group of students to assume the identity of new teachers in a school given responsibility to prepare a report to staff on assessment strategies.

Two students from the class were nominated, by their usual lecturer, to be typical students who might be suitable to observe as part of the pilot study. The sampling choice was made on conceptual grounds, not representative (Miles & Huberman, 1994; LeCompte & Preissle, 1993) and focused on the 'typical case'. Miles and Huberman (1994) suggest that the typical case, which highlights what is normal or average, is a sampling method which can have 'great payoff' (the others are the 'negative' or 'disconfirming' instance, and the 'exceptional' or 'discrepant' instance). The students chosen also needed to be comfortable working together, and so they needed to be chosen as a pair rather than two individuals who would be forced to work together. On the day of the pilot study, one of the nominated students was absent. The remaining nominated student was asked if she would participate in the study, and the second participant was the person with whom she had chosen to work.

The two students were placed at a computer in the room which had been set up with a video camera nearby. The video camera was positioned to allow simultaneous observation of the program and the students themselves. This was done by placing it on a tripod at an angle to the screen, which enabled the camera to capture an image of the screen and a side view of the two students. A microphone was placed on the table in front of the students next to the computer monitor to record the conversation the students had with each other as they worked on the collaborative task.

As the students worked on the investigation, the lecturer moved around the room assisting the groups as required. The lecturer was thoroughly familiar with the notion of providing scaffolding, but the expectation of this role for the purpose of the research

was supported by the provision of written guidelines (see Appendix 5). Students used the assessment multimedia program to complete the given task for a period of 120 minutes in the first week, which was the class time remaining after the introduction and discussion on assessment. In the second week, students worked on the program for 120 minutes. At the end of this period, the lecturer asked all the students to come to a 'staff meeting' to present their findings. Two groups were asked to present their reports to the remainder of the class at the staff meeting which was held around the large table in the middle of the room.

At the end of the second week, students were thanked for their participation in the research and from that point returned to their regular class. In the afternoon of the class in the second week, the two students, who had agreed to be observed using the assessment program, were interviewed separately by appointment.

Interviews

In order to consolidate the information gained from observing the students using the interactive multimedia program, and to provide corroboration of the data from alternate sources (Eisner, 1991), interviews were conducted with the students in both the pilot study and the main study. Patton (1990) has described the usefulness of interviewing in finding out information which may be difficult to determine in any other way:

> We interview people to find out from them those things we cannot directly observe. The issue is not whether observational data is more desirable, valid or meaningful than self-report data. The fact of the matter is that we cannot observe everything. We cannot observe feelings thoughts and intentions. We cannot observe behaviours that took place at some previous point in time. We cannot observe situations that preclude the presence of an observer. We cannot observe how people have organised the world and the meanings they attach to what goes on in the world. We have to ask people questions about those things. (p. 278)

Interviews and surveys have been broadly categorised by researchers into two categories. Some researchers have developed categories based on the type of person being interviewed, for example, children, women or handicapped people (cf., LeCompte & Preissle, 1993). LeCompte and Preissle point out that such a categorisation can be confusing, and that the second commonly used method of categorisation on the basis of the purpose or structure of the interview is more useful.

Denzin (1989) and Patton (1990), among others, have summarised the most frequently employed interviewing strategies employed in educational research according to the second category described above, the structure of the interview. These are presented in Table 5.3 moving from least structured at the top of the table, to most structured at the bottom.

Table 5.3: Categories of interviews (Patton, 1990 and Denzin, 1989)

Denzin (1989) Type of interview	Patton (1990) Type of interview	Characteristics
Least structured		
	Informal conversational interview	Questions emerge from the immediate context and are asked in the natural course of things; there is no predetermination of question topics or wording.
Nonstandardized interview	Interview guide approach	Topics and issues to be covered are specified in advance, in outline form; interviewer decides sequence and wording of questions in the course of the interview.
Nonschedule standardized interview		Questions and probes are determined in advance but there is flexibility in the interview, e.g., in the sequence of questions, depending on the responses of the interviewees.
Schedule standardized interview	Standardised open-ended interview	The exact wording and sequence of questions are determined in advance. All interviewees are asked the same basic questions in the same order. Questions are worded in a completely open-ended format.
	Closed, fixed response interview	Questions and response categories are determined in advance. Responses are fixed; respondent chooses from among these fixed responses.
Most structured		

Patton (1990) points out that these categories represent pure types, and that in practice, any one interview may employ several of the interviewing strategies together. The interviewing technique used in this study most closely resembles Denzin's *Non-scheduled standardised interview*, or using Patton's categorisation, elements of both the *Standardized open-ended interview* and the *Interview guide approach* shaded in Table 5.2. This approach was chosen because a framework of topics was required to ensure that certain areas were not inadvertently missed if they did not arise naturally in the course of the interview. There was also the danger that if the interviews were not focused, too much superfluous information would be collected which would 'compromise the

efficiency and power of the analysis' (Miles & Huberman, 1994, p. 35). However, as only a single researcher was working with the data, it was not necessary to strictly standardise the questions for a number of different interviewers. Some flexibility was also required to enable follow-up questions to suit individual responses.

The interview questions

Patton (1990) has identified six types of interview questions:

1. *Experience or behaviour* questions about what people do, or have done;

2. *Opinion or values* questions about what people think about their experiences and the interpretive processes;

3. *Feeling* questions about the emotional responses people have to their experiences and thoughts;

4. *Knowledge* questions about factual information the respondent has (as opposed to opinions and feelings);

5. *Sensory* questions about what is seen, heard, touched, tasted and smelled; and

6. *Background or demographic* questions about background characteristics of respondents such as age, occupation, income and so on (pp. 290-293).

The questions asked of the two students at the conclusion of their investigation using the interactive multimedia program on assessment are presented in Table 5.4 below, together with an indication of the question's type (according to Patton's classification) and a brief rationale for its use. The majority of the questions are Types 2 and 3: opinion and feeling questions. There are some experience and demographic questions (Types 1 and 6) but no knowledge or sensory (Types 4 and 5) questions. There was no attempt to question students about their overt knowledge of assessment strategies during the interviews as this data was to be collected by other means in Part 5 of the research, nor was it felt necessary or appropriate to elicit any sensory information.

Table 5.4:   Schedule, classification and rationale of interview questions: Pilot study

Question	Type of question				Rationale
	1 Exp	2 Opin	3 Feel	6 Dem	
Background and IMM experience					
The purpose of this interview is to get some information that will help designers of multimedia programs to design programs more effectively. As someone who has experienced multimedia in your course, you are in a good position to describe your experience and how you found it. Explain right to withdraw and that the interview will be taped.					Explanatory and introductory comments.
Ask name, age and year of course				✔	Brief demographic information.
What did you think of the interactive multimedia program on assessment?	✔				Open-ended question to encourage the respondent to speak descriptively rather than forming the habit of providing short answer, routine responses (Patton, 1990). This question permits the respondent to reply in own terms and language.
Have you ever used a multimedia program before? If so, which titles?	✔				Background questions to ascertain the level of experience with interactive multimedia programs.
Have you used any multimedia in your course before? If so, which?	✔				
Effectiveness of program and pattern of use					
When you were working with the multimedia program, how did you find what you were looking for? *What strategies did you develop?*	✔				Experience questions to encourage the respondent to review the program before offering more detailed opinion.
What were the strengths of the program? *What were the weaknesses of the program?*		✔			Presupposition questions (i.e. the questions assume the program *has* strengths and weaknesses, and can thus elicit useful information) (Patton, 1990)
How effective do you think the program is?		✔			Opinion question which seeks summary comments and reinforcement of previous answers.
What have you learned from this program?		✔			Open-ended, opinion question on the students' assessment of learning rather than a knowledge question.

Question	Type of question				Rationale
	1 Exp	2 Opin	3 Feel	6 Dem	
What are some of the things you really liked about the program? *What are some of the things you disliked about the program?*			✔		Feeling questions which are aimed at finding out the respondent's emotional response to the program.
If you had the power to change the program, what would you make different?		✔			Opinion question which seeks recommendations for change or improvements to the program.
If a friend of yours was about to use the program for the first time, what advice would you give?		✔			Projective question which asks the respondent to take on the role of 'expert'.
How do you think your work with the program will affect your performance in the classroom as a mathematics teacher?		✔			Speculative question which can be compared to the transfer study in Part E of the research.
Effect of critical elements of situated learning					
We've been talking about your experiences with the multimedia program in general. I'd like now to ask your opinion on some of the specific features of the program.					Transition statement to move onto the discussion of each of the critical elements of the situated learning model.
Authentic context					
The program attempted to put assessment strategies into a real-life context. What did you think about the context of the classroom?		✔			Open-ended opinion question on authentic context.
There are a number of different ways you could have learnt about assessment strategies. What did you think about doing it this way?		✔			Opinion question to determine whether the students relate the learning environment to the real-life context of teaching in a school.
What did you really like about the classroom context? *What did you dislike about the classroom context?*			✔		Feeling questions which are aimed at finding out the respondent's emotional response to the authentic context.
Authentic activity					
What did you think of the activity you were given to do with the program? (The activity prompted by the letter from the parent.)		✔			Open-ended opinion question on the activity.
How did you go about completing the task? What stages were there?	✔				Question aimed at eliciting information on how the complex task was broken up.
How did you find the time allocated to complete the activity? Too long? Too short?		✔			Question seeks opinion on whether sustained thinking was possible within time allocated.

Question	Type of question				Rationale
	1 Exp	2 Opin	3 Feel	6 Dem	
How did you feel about taking on the role of a teacher with a complex report to complete? Did you feel like a real teacher?			✔		Feeling questions to elicit emotional response to the activity.
Multiple perspectives					
The activity required you to consider a question from a number of different perspectives: the parents', teachers' and children's perspectives. How did you feel about this task?			✔		Feeling question to determine how the student responded to the requirement of examining the resource a number of times from different perspectives.
How did you approach the task?	✔				Experience question to seek strategies the student may have used in examining the resource.
What were the strengths of examining the resource from multiple perspectives? *What were the weaknesses?*		✔			Presupposition questions to elicit the respondent's opinion on the approach.
Expert performances					
What did you think of the video segments showing teachers using the assessment strategies in the classroom? *How much did you learn from the teachers?*		✔			Open-ended opinion questions to elicit information on whether the respondent values access to expert performances.
What did you like about the video segments in the classroom? *What did you dislike about them?*			✔		Feeling questions aimed at finding out the respondent's emotional response to the expert performances.
Collaboration					
During the last two weeks you've worked with a partner on the program. *How have you felt about this arrangement?*			✔		Feeling question on whether the respondent enjoyed working as part of a team.
What role did you have in the group?	✔				Experience question which seeks information on whether students shared roles or assigned specific, individual roles to contribute to the completion of the task.
What were the advantages of working in pairs? *What were the disadvantages?*		✔			Presupposition questions to elicit the respondent's opinion on working in pairs.
Reflection					

Question	Type of question				Rationale
	1 Exp	2 Opin	3 Feel	6 Dem	
How did the program enable you to reflect on your learning as you completed the activity?		✔			Presupposition question to obtain information on whether students reflected on the issues as they used the program.
How did your partner help you to reflect on your learning?		✔			Opinion question on whether the reflection was collaborative.
Did you feel you had sufficient opportunities to reflect on what you were learning?			✔		Feeling question to ascertain whether opportunities to reflect were possible.
Articulation					
How did you feel about giving a report to the class?			✔		Feeling question to ascertain respondent's reaction to articulation of learning.
How did the presentation of your report to the class help your learning?		✔			Opinion on whether articulation contributes to the learning process.
Coaching and scaffolding					
What kinds of assistance did your lecturer provide as you worked on the activity?	✔				Experience question to review the interactions with the lecturer.
How effective was the assistance provided by your lecturer?		✔			Question aimed at respondent's opinion on the usefulness of the lecturer's support.
How did you feel about having your lecturer available as you worked on the activity?			✔		Feeling question on whether the respondent needed or wanted lecturer's support.
Authentic assessment					
How did you feel about giving your report as if you were a teacher reporting at a staff meeting?			✔		Feeling question on how students felt about the assessment requirements.
What were the strengths of presenting an authentic report? *What were the weaknesses?*		✔			Presupposition questions to elicit the respondent's opinion on the assessment method.
Closing comments					
You've been very helpful. Do you have any other thoughts or feelings on using the assessment strategies interactive multimedia package? *Thank you.*					Final open-ended question to obtain any further comment. Closing remarks and thanks.

The students were interviewed separately in a quiet room, in May 1996, using the interview questions given in Table 5.4 above. An expanded version of the schedule was produced for use in the interview to enable notes to be taken. The interviews were taped on a small audio cassette recorder.

Four additional strategies were employed during the interviews to encourage the students to give thoughtful, succinct and complete answers:

1. Allowing a suitable waiting period after the question is asked to give the respondent time to think (Fetterman, 1989)

2. Making support and recognition comments and gestures to encourage the respondent to keep talking (Patton, 1990)

3. Using 'detail-oriented probes' with follow-up questions beginning with the words 'who,' 'what', 'when', 'how' and 'in what way?' (Patton, 1990)

4. Taking notes as a device to control the length of the respondent's answer—such as putting the pen down and leaning back to indicate that the response is no longer relevant—rather than interrupting the respondent (Patton, 1990).

The interviews lasted for 45-60 minutes each, and at their conclusion the tapes were transcribed for analysis.

Findings of the pilot study

The pilot study revealed a number of problems and inadequacies that needed to be attended to before the main study was attempted. The adjustments that needed to be made related to the interactive multimedia program itself and the practicalities of the data collection methods.

Problems with the interactive multimedia program

The interactive multimedia program on assessment had been completed approximately eight days before the pilot study commenced. It was expected that problems would emerge with the software which had not been evident in smaller trials, and this proved to be the case. The use of the program in the pilot study revealed several 'bugs' which needed to be attended to, such as some of the CDs did not allow students to highlight and select text. The pilot study also revealed design faults such as the fact that students could not save the *Notebook* and then open it again from within the program to continue writing notes from one session to the next. A full list of problems is provided in Appendix 6. None of the bugs were serious enough to impede the data collection of the pilot study. Nevertheless, all of the problems were brought to the

attention of the computer programmer who corrected them before the CD-ROMs were recut for use in the main study.

Problems with the data collection methods

The pilot study also revealed some problems with the data collection, primarily the recording equipment, which impeded efficient recording of the students' use of the program and their dialogue with each other. For example, the external microphone attached to the video camera had a very sensitive connection resulting in intermittent problems with the sound recording on the videotape. All the problems encountered with equipment, their causes (if known) and solutions are listed below in Table 5.5.

Table 5.5:   Equipment problems, causes and solutions detected in pilot study

Problem	Cause	Solution
Sound problems with the computer used to view the program. The audio track on some of the video segments did not play.	Unknown. Intermittent fault.	Replacement computer and monitor brought into the lab in the second week of the study.
No sound on the video recording of the students working on the assessment program	Loose connection between the external microphone and the video camera.	Practice with the correct position of the microphone jack, and backup audio on a separate cassette recorder.
Students' positions at computer meant that one student obscured the view of the other from the camera.	Badly positioned video camera.	The camera was moved to a better angle to ensure both students were visible in a comfortable working position.
Break in recording when the video tapes had to be replaced.	Tapes' recording time (45 minutes each) were shorter than the full session	Backup audio cassette recorder used. Tapes replaced at different times to ensure overlap of data recording.

These data collection problems were all rectified by the second week of the pilot study ensuring that adequate data was able to be collected. No data collection problems were evident with the interviews conducted with the two students after the class sessions. The interviews were audible and distinct, and easily transcribed.

Part D: The implementation of the interactive multimedia program as a situated learning environment

Part D of the research investigated the use of an interactive multimedia program on assessment techniques designed as a situated learning environment. The study examined students' use of the program in their normal classroom environment, with particular interest in their use of higher-order learning while using the program, and the relative influence of the critical elements of the situated learning environment.

The participants

The participants were six second year preservice secondary teachers (three groups of two) studying mathematics method. Qualitative research is usually done with small samples of people, and this is consistent with Firestone's contention that the most useful generalisations from qualitative studies are analytic, not sample-to-population (Firestone, 1993 cited in Miles & Huberman, 1994).

The lecturer was asked to recommend six students who might be considered as 'typical case' with an equal representation of gender, although the total class for the semester of the study was unusually small, and the entire class was comprised of just eight students. Students were grouped in friendship or collegiate groups, as they preferred, prior to selection to maximise collaborative interactions. The lecturer selected three groups which included all three women students and three of the five men. This resulted in one male pair of students, one female pair, and a male and female pair.

For university administrative purposes, the class had been combined with another class of 18 fourth year Diploma of Education students. All the students in this group, together with the second year students in the study, used the program together in the computer laboratory over 3 weeks of the unit semester.

Procedure

The study commenced in Week 5 of the semester. The lecturer introduced the subject of assessment, and the multimedia program and its capabilities to the class. The lesson plan is provided in Appendix 7. Students were given several documents to assist in their use of the program and the efficient collection of data:

1. *A handout of the investigation* to be conducted using the interactive multimedia program on assessment (as shown in Figure 4.12). Investigations were provided in the electronic notebook of the program, but a hard copy enabled the students

to have ready access to the details at all times. All three groups of students in the study were given the same investigation, but other groups from the fourth year level were given alternatives to provide a variety of tasks.

2. *A summary of the assessment requirements* for the investigation, including due dates and administrative information. The assignment required each group of students to provide both a presentation to the class in the third week, together with a written report to be submitted 10 days later.

3. *A help sheet and quick guide to getting started* (as shown in Figure 4.14)

4. *A permission slip* to obtain the students' informed consent to participate in the study (Appendix 8)

5. *A checklist of guidelines for speaking* in such a way as to maximise the efficient collection of data through the recording equipment (Appendix 9).

All students in the class used the interactive multimedia program on assessment over a period of 5 hours (2 weeks lecture time). Students' work sessions were observed, and videotaped to allow simultaneous observation of the program and the students as they used it, as for the pilot study. The three groups of students worked on the interactive multimedia program, with their lecturer available for the entire period. The lecturer provided assistance to the students as required, and in keeping with the criteria of a situated learning environment established in Part A of the study, and as provided in writing to the lecturer as in Appendix 5.

Assessment of the investigation

In the third week of the study, students were required to present their reports to the class. When taken together with the 4th year class, all five investigations had been done by at least two groups.

Students generally concentrated on their own investigations and were not aware of the tasks being undertaken by the other groups. In order to provide a context for each presentation, a series of memos and announcements were prepared which introduced the presentation in an authentic manner, for example, an agenda for the school council meeting with the presentation as one of the items. The context for the investigation undertaken by the students in the study is given in the form of a note to staff about a special staff meeting. All the memos and letters were brief and they were reduced proportionally in order to fit them all on to a single page. This collage of documents was given to all the students in the class to enable them to quickly acquaint themselves with the purpose of each investigation before it was presented.

Each memo also asked the 'audience', be they school council members, board members or staff, to evaluate the proposals that were put before them. In order to do this in a manner which enabled peer assessment of the presentations, students were given evaluation sheets (see Appendix 10). Every student evaluated each presentation using four different criteria:

1. *Effectiveness of argument:* How persuasive was the group's proposal?

2. *Proposal's practicality:* Were the suggestions practical and able to be implemented?

3. *Argument well supported:* Was there sufficient evidence to support the proposal?

4. *Presentation skills:* How well did the group present their report?

All the groups presented their reports during the scheduled class time of the third week. The students seemed to enjoy the chance to role play and most stepped into their roles with enthusiasm and good humour. For example, one student dressed the part in a shirt, tie and suit because he was going to address 'the teachers at the Teacher Development Night'. Most students commenced their presentations with a suitable introduction, for example, introducing themselves if they would have been unknown to the group, and with appropriate greetings such as 'Good afternoon, staff'. Several students made use of humour, such as one who prefaced his remarks with: 'When I was a student teacher, many years ago ...'.

At the conclusion of each presentation, the lecturer asked students to take a minute or two to fill in their evaluation sheets. The lecturer collected the evaluations at the conclusion of the class, and compiled the marks to assign a group mark for each presentation which was used as part of their unit assessment.

Interview questions: Main study

The interview schedule was revised for the main study, with the addition of two questions to the section on authentic assessment. The additional questions were provided to more accurately reflect the written as well as oral requirements of the main study—the pilot study students were not assessed on their work with the multimedia program as part of their unit requirements. The questions are given below in Table 5.6.

Table 5.6:   Schedule, classification and rationale of additional interview questions: Main study

Question	Type of question				Rationale
	1 Exp	2 Opin	3 Feel	6 Dem	
Authentic assessment					
How did you feel about writing up your proposal in the form of an authentic report?			✔		Feeling question on how students felt about the written component of the assessment requirements.
How does this type of assessment compare to more traditional forms of assessment?		✔			Opinion question to elicit the respondent's opinion of the nature of 'traditional assessment' and how it compares to authentic assessment.

The six students were interviewed separately, by appointment in August/September 1996. Despite several students failing to appear at the appointed time, persistent reminders and new appointments ensured that all the interviews were completed within a three week period following the presentations to the class. The interviews were taped and transcribed for analysis.

Part E: The transfer study

The transfer study investigated the extent of the preservice teachers' use of the different assessment techniques featured in the interactive multimedia program, in their professional practice in schools. The study was conducted at the conclusion of the students' second professional practice period, beginning approximately 8 weeks after the commencement of the Part D study (see Appendix 11 for the research plan).

The participants

The participants were the 6 preservice teachers used in Part D of the research, and 6 teachers who supervised the students in their professional practice in schools.

Procedure: Interviews of supervising teachers in schools

Three weeks after the conclusion of their use of the interactive multimedia program on assessment, the students had two weeks professional practice in schools. Each student went to a different school in the metropolitan area and was assigned a supervising

teacher for the duration of the teaching practice. During the two week period, each student taught mathematics classes that were normally taken by the supervising teacher, and guidance was provided by that teacher in both the planning and the execution of the lessons. It was felt that the supervising teacher would be suitable to interview because he or she was in a good position to advise on the student's use of assessment strategies during the professional practice period. In contrast, the supervising lecturers from the university observed at most only two lessons taught by each student and would have a limited appreciation of assessment strategies used by the students in their lessons. A list of supervising teachers in schools was obtained from the Professional Practice Office at the University. Each teacher was contacted at the school by telephone and advised of the study in the following manner:

1. An introduction was made informing the teacher of the role of the researcher in the University and the nature of the PhD research.

2. The teacher was told that research was being conducted into multimedia, and into how knowledge learned from programs transfers to teaching practice.

3. The teacher was asked whether he or she was willing to answer a few questions about the professional practice student. The teacher was advised that the student had been observed and interviewed in an earlier part of the research.

4. Assurance was given that the information disclosed would be entirely confidential and would not be used to assess the student's performance on his or her professional practice.

5. The teacher was then asked if he or she would prefer the researcher to visit the school or to answer the questions over the telephone. If he or she chose the latter, the teacher was asked permission for the interview to be taped and conducted on a speaker telephone.

6. The teacher was told that a consent form would also need to be signed, and this would be sent together with a reply-paid envelope for return of the document (Appendix 12).

7. An appointment time was arranged for the conduct of the interview.

All the teachers agreed to be interviewed, and all chose to be interviewed on the telephone. At the time of the interview, the contact was made via the school switchboard and the interview was recorded by placing a tape-recorder adjacent to the speaker telephone. The teachers were interviewed using the interview schedule given in Table 5.7, which gives each question together with a rationale for its choice. A variation of this table was used during the interview, with space for notes and records.

Table 5.7: Schedule and rationale of interview questions: Supervising teachers

Question	Rationale
Which classes and year levels did [name of student] teach, or participate in teaching?	Possibly useful question to relate to students' comments during use of the interactive multimedia program, particularly to their beliefs about assessment techniques appropriate to different year levels.
Was [name of student] required to assess student learning during each lesson, or at any time during the professional practice?	Question to ascertain whether assessment is seen by the supervising teacher as an integral part of the teaching process, and whether the student-teacher had opportunities to implement assessment strategies.
Types of assessment employed	
Did [name of student] give students any paper and pencil tests to perform?	Question to ascertain whether the student-teacher used any of the assessment techniques grouped under the heading *Testing* in the interactive multimedia program. The question will also give information on the use of the more traditional pencil and paper tests to assess student learning.
If yes, how were these tests administered and followed up?	Follow-up question to determine the manner in which these tests were used, that is, whether they were used in more innovative or in traditional ways.
Did you suggest this procedure, or [name of student]?	Question to investigate the extent of influence of the teacher over the student-teacher's actions.
Did [name of student] use questioning to assess students' understanding, for example, open ended questions or factual recall questions? *If yes, how was this done?* *Did you suggest this procedure, or [name of student]?*	Question, and follow-up, to ascertain whether the student-teacher used any of the assessment techniques grouped under the heading *Questioning* in the interactive multimedia program.
Did [name of student] ask students to report their learning in either an oral or written form, such as in presentations to the class, portfolios, written investigations or models? *If yes, how was this done?* *Did you suggest this procedure, or [name of student]?*	Question, and follow-up, to ascertain whether the student-teacher used any of the assessment techniques grouped under the heading *Reporting* in the interactive multimedia program.
Did [name of student] work individually with students to assess understanding of mathematics? *If yes, how was this done?* *Did you suggest this procedure, or [name of student]?*	Question, and follow-up, to ascertain whether the student-teacher used any of the assessment techniques grouped under the heading *Interviewing* in the interactive multimedia program.

Question	Rationale
Did [name of student] observe students either with the use of checklists or anecdotal records to assess performance in mathematics? *If yes, how was this observation done?* *Did you suggest this procedure, or [name of student]?*	Question, and follow-up, to ascertain whether the student-teacher used any of the assessment techniques grouped under the heading *Observing* in the interactive multimedia program.
Did [name of student] use any self-assessment techniques with students such as journal writing, self-questioning prompts or peer assessment? *If yes, how was this done?* *Did you suggest this procedure, or [name of student]?*	Question, and follow-up, to ascertain whether the student-teacher used any of the assessment techniques grouped under the heading *Self-assessment* in the interactive multimedia program.
Do you think [name of student] attended well to assessment aspects of the lessons taught?	Question to allow general comments on the student's use of assessment strategies.
Do you have any other observations or comments on [name of student]'s use of assessment techniques? *Thank you.*	Final question to allow general comments and observations which may not have been covered by the other questions.

At the conclusion of the interviews, the audio tapes were transcribed for analysis.

Procedure: Interviews with students

Two to three weeks after the conclusion of the students' professional practice in schools, they were interviewed using a variation of a technique suggested by Miles and Huberman (1994) on making and testing predictions, in order to obtain useful data on the extent of transfer. The prediction technique allows students to comment on their performance in the area of assessment in general, and then to provide further specific data on supporting and negating factors associated with their use of the assessment techniques. A prediction was made by the researcher on the likely outcomes of the interactive multimedia program, the knowledge gained by students and its impact on professional practice. The prediction was that:

> In your mathematics classes on your teaching practice, you will use a variety of assessment techniques to assess student learning, other than pencil and paper tests.

Miles and Huberman (1994) suggest that this prediction technique can be completed by mailing the relevant documents to the participants in the study. However, it was

decided to use the technique in person with the students, and to tape the interview as it allowed follow-up questions and thus enabled the collection of a richer bank of data.

Students were consulted individually. First, they were given the prediction (see Appendix 13) and asked to judge its accuracy by specifying the actual situation in their professional practice experience. It is suggested by Miles and Huberman (1994) that this step helps to yield a more extensive database of information—students often suggest factors which have not been foreseen—and the students are not 'contaminated' by the researcher's frame of reference. Students were asked the question and the response was noted by the researcher on the form, and also recorded in full on the audio tape.

Secondly, students were asked to consider the relevant impact of supporting and negating factors in accounting for their experience on professional practice (see Appendix 14). For the prediction, a list of factors supporting the outcome, and a list of factors working against it, was prepared. These factors were suggested in both the teacher and mathematics education literature (e.g., Reynolds, 1992; Sullivan, 1989; California Mathematics Council, 1995; Tabachnick & Zeichner, 1984), and in the comments provided by the supervising teachers in the interviews conducted earlier. The factors listed which might have supported the prediction coming true, that is, that the students did use a variety of assessment techniques, were:

- Encouragement and support from supervising teacher,

- Sufficient time to plan lessons carefully,

- Aware of other strategies from observing other teachers on professional practice,

- Aware of other strategies from using the multimedia program on assessment,

- Aware of other strategies from the methods you experienced as a student yourself.

The factors listed which might have worked against the prediction coming true, that is, that the students used mainly pencil and paper tests, were:

- Supervising teacher dictated the type of assessment for each lesson,

- Not aware of any other strategies that were appropriate,

- Pencil and paper is best for grading purposes on teaching practice, because any other method is too difficult to follow up,

- Not enough time to prepare a variety of assessment techniques,

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- There is no need for assessment of learning in classes taught during teaching practice.

The students were given the second sheet containing the supporting and negating factors (Appendix 14) and asked to think about the situation that actually occurred on the teaching practice, to look at each factor and rate whether it was an important factor in the outcome, a relevant but not important factor, or not relevant at all. Students were asked to justify their choice for each factor and these comments were taped and later transcribed.

Finally, students were given a list of the assessment techniques featured in the interactive multimedia program on assessment (see Appendix 15) and asked whether they had employed any of the strategies listed. Rather than going through all 23 strategies, the strategies were grouped. The questions asked then mirrored the questions asked of the supervising teachers to assist structural corroboration of data. For example, rather than asking the student: 'In your teaching practice, did you interview students in a structured way? Did you interview students in an open way? Did you interview parents?', the student was simply asked 'On your teaching practice, did you use interviewing to assess their understanding of mathematics?', a question which covers the *Interviewing* group of strategies. The full schedule of interview questions, together with a rationale, is provided in Table 5.8.

Table 5.8: Schedule and rationale of interview questions: Students

Question	Rationale
Were you required to assess student learning during each lesson, or at any time during the professional practice?	Question to ascertain whether the student felt he or she had discretion over the implementation of assessment strategies.
Types of assessment employed	
On your teaching practice, did you observe students with the aid of checklists or anecdotal records?	Question to ascertain whether the student used any of the assessment techniques grouped under the heading *Observing* in the interactive multimedia program
Did you use questioning to assess students' understanding?	Question to ascertain whether the student used any of the assessment techniques grouped under the heading *Questioning* in the interactive multimedia program.
Did you use interviewing to assess students understanding of mathematics?	Question to ascertain whether the student used any of the assessment techniques grouped under the heading *Interviewing* in the interactive multimedia program.
Did you use any tests with students?	Question to ascertain whether the student used any of the assessment techniques grouped under the heading *Testing* in the interactive multimedia program. The question will also give information on the use of the more traditional pencil and paper tests to assess student learning.
Did you ask students to report their learning in either an oral or written form?	Question to ascertain whether the student used any of the assessment techniques grouped under the heading *Reporting* in the interactive multimedia program.
Did you use any self-assessment techniques with students?	Question to ascertain whether the student used any of the assessment techniques grouped under the heading *Self-assessment* in the interactive multimedia program.
Closing questions	
In what ways did the use of the interactive multimedia program on assessment influence the assessment strategies you used on your teaching practice?	Opinion question to elicit the respondent's opinion of the impact of the multimedia program on his or her classroom practice.
Do you have any other observations or comments on your use of the multimedia program and your use of assessment techniques? *Thank you.*	Final question to allow general comments and observations which may not have been covered by the other questions.

The students were interviewed in October 1996. At the conclusion of the interviews, the students were thanked for the considerable amount of time they had put into the research. The interviews were transcribed for analysis.

In transcribing all the interviews in the study, no attempt was made to note non-verbal cues, physical expressions or body language. Only the words were transcribed. Halliday (1985) points out that there is consequent loss of meaning, but a transcript which attempts to incorporate every feature quickly becomes so cluttered as to be unreadable. Halliday suggests it is important to focus only on those aspects of speech which are important for the purpose of the study, and in this case the most important aspects were opinions, feelings, demographic, and experience as noted in the rationale for all the interview questions.

Data planning matrix

LeCompte and Preissle (1993) suggest that a data planning matrix is a useful tool in planning research. The matrix prepared in planning the current research is provided below (Table 5.9) as a summary of the relationship between the research questions and the parts of the research.

Table 5.9: Data planning matrix (Table headings adapted from LeCompte and Preissle, 1993)

Part	Research question	Rationale	Data required	Source of data
A		To define the critical elements of a situated learning model	Research, evaluation and theoretical papers on situated learning from the mid 1980s to the present.	Research journals and conference papers.
B		To develop an interactive multimedia learning environment based on the critical elements of situated learning	Mathematics education method	Mathematics education content experts
C & D	1. How do students use an interactive multimedia program designed to incorporate the characteristics of a situated learning environment?	To discover how students progress through the program, the options they choose to pursue and the nature of their interactions as they proceed.	Observation and video recordings of students using the program Interviews with students	Normal classes Students by appointment
C & D	2. How important to students is each of the critical characteristics of situated learning in the interactive multimedia learning environment?	To assess the importance of, and the relationship between, the elements defined as critical characteristics.	Observation and video recordings of students using the program Interviews with students	Normal classes Students by appointment
C & D	3. What types of higher-order thinking do students employ while using an interactive multimedia program based on principles of situated learning?	To assess the quality of higher-order thinking and cognitive processes employed by students in the learning environment.	Observation and video recordings of students using the program Interviews with students	Normal classes Students by appointment
E	4. How effective is a situated learning interactive multimedia program based on principles of situated learning in promoting transfer of knowledge to classroom practice?	To assess the degree to which assessment techniques learnt in the interactive multimedia package are used in classroom practice.	Student interviews after practicum using predictions Interviews with supervising school teachers	Students by appointment Teachers by appointment

Ethical considerations

It was important for the research to follow strict ethical guidelines laid down by the University in order to protect the rights of participants, and ensure that the research

was conducted in a fair and equitable manner. Approval was also required by the University's Ethics Committee, who monitor all research conducted within the University using human or animal subjects. The following sections describe how ethical issues in the conduct of the research have been addressed.

Informed consent

All participants were informed of the nature and extent of the research prior to commencement. Eisner (1991) points out that in qualitative research it is sometimes difficult to inform participants precisely about the outcomes of the research, as this is often not known, except in the most general terms:

> We all like the idea of informed consent, but we are less sure just who is to provide that consent, just how much consent is needed, and how we can inform others so as to obtain consent when we have such a hard time predicting what we need to get consent about. (p. 215)

Nevertheless, an attempt was made to provide clear information to participants, particularly about their own roles in the research. As Miles and Huberman (1994) point out, respondents will try to protect themselves if there is mistrust: 'Weak consent usually leads to poorer data' (p. 291). Participants—both students and supervising teachers—were required to sign an agreement to participate which provided full details of the aims of the research (see Appendices 8 and 12).

Confidentiality of records

All participants were given a pseudonym, which bore no resemblance to their own name, for the duration of the research. No use of real names or other identifying data, such as specific course name or calendar year, was used. Access to the recorded videotapes and audiotapes was confined to the researcher, and one transcriber for a short period of time. Videotapes and transcripts and all other records were stored securely in the researcher's home. It is intended to retain transcripts for five years in secure storage.

Possible risks to participants

There were no apparent risks to participants in the study. Students used the program in their normal class time, and were provided with appropriate refreshment breaks. All participants had the option of withdrawing at any time.

One possible ethical issue arose in the fact that only a small number of students out of a class were to have access to computer-based learning materials which may be beneficial to the other students as well. To overcome this difficulty, all the students in both the pilot and the main study classes used the materials concurrently, although only eight were used in the research.

Payment for participation

Participants were not offered any incentive payment to be part of the research. All freely agreed to take part without recompense. However, at the conclusion of the interviews, each participant was given a book voucher in recognition of the time and effort they has expended on the research, in particular, the interviews.

Ensuring validity and reliability

Ensuring for validity and reliability is a fundamental requirement of quantitative research (Campbell & Stanley, 1966). However, a number of researchers have commented on the difficulty of ensuring the validity and reliability of the instruments used in qualitative research (e.g., Eisner, 1991; Fraenkel & Wallen, 1993). Nevertheless, it was important to ensure that some confidence could be placed in the findings of the current research by attending to the validity and reliability of the research procedures.

One particular aspect of the present research required a specific reliability check to ensure that some confidence could be held in the numerical data relating to students' use of higher-order thinking as they used the multimedia program, and this is described in greater detail in Chapter 8 where the full context of its use can be better appreciated.

A number of other techniques have been identified, to assist qualitative researchers to ensure that their methods, inferences and conclusions are both appropriate and consistent over time. Some of these procedures are listed in Table 5.10 together with an explanation of how the technique was used in the current research.

Table 5.10:   Procedures to ensure validity in qualitative research

Procedure	Implementation
❏ Use of structural corroboration or triangulation, by the use of multiple sources of data (e.g., Eisner, 1991; LeCompte & Preissle, 1993; Fraenkel & Wallen, 1993; Guba, 1981; Miles & Huberman, 1994 ; Denzin, 1989)	❏ Corroboration by data source, persons (preservice teachers and their supervising teachers), times (before and after teaching practice), and by method, (observation, interview, documentation)
❏ Collection of referential materials, e.g., documents, videotapes, audio recordings and other 'slice-of-life' data items against which findings can be tested (Guba, 1981; Eisner, 1991; Fraenkel & Wallen, 1993)	❏ Videotapes of students using the multimedia program, records, observation notes, taped interviews, student assignment reports, and videotapes of students presenting their oral presentations to the class provided referential material
❏ Consensual validation, or agreement among other researchers that the description and interpretation of the research are right (Eisner, 1991; Guba, 1981; LeCompte & Preissle, 1993)	❏ Research proposal reviewed by two external reviewers (academics) as part of University PhD requirements ❏ Formal review of research proposal at a public forum as part of University PhD requirements ❏ Literature review, critical characteristics of situated learning, theoretical framework and pilot study findings reviewed through conferences and publications (e.g., Herrington & Oliver, 1995a; Herrington & Oliver, 1995b; Herrington & Oliver, 1996; Herrington & Oliver, 1995c)(See Appendix 16 for a full list of papers and presentations which have allowed public scrutiny and evaluation or the research during the preparation of the thesis) ❏ When numerical data was involved, validation of coding was provided by two academics (described in Chapter 8)
❏ Looking for negative evidence (Miles & Huberman, 1994; Howe & Eisenhart, 1990)	❏ Identification of negative instances and careful consideration to 'the proportion of negative to positive evidence' (Miles & Huberman, 1994, p.271)
❏ Checking for researcher effects (Miles & Huberman, 1994; LeCompte & Preissle, 1993; Fraenkel & Wallen, 1993)	❏ Low profile adopted by researcher; data collection was as unobtrusive as possible (some researcher effect may have occurred, however, and this is discussed in the *Limitations of the research* in Chapter 10)
❏ Obtaining confirmatory feedback from the informants themselves (Miles & Huberman, 1994; Guba, 1981)	❏ Particularly in the follow-up interviews, students were asked to confirm the perceptions and conclusions being drawn, e.g. 'Am I right in assuming then that the prediction is true?'

It is worth noting, however, that there is an implicit incompatibility between standard quantitative notions of validity and that possible in qualitative research. Schofield (1990) cites Krathwohl's (1985) assertion that 'The heart of external validity is

replicability', and goes on to point out the essential difference at the heart of the qualitative approach:

> The goal is *not* to produce a standardized set of results that any careful researcher in the same situation or studying the same issue would have produced. Rather it is to produce a coherent and illuminating description of and perspective on a situation that is based on and consistent with detailed study of that situation. Qualitative researchers ... do not expect other researchers ... to replicate their findings in the sense of independently coming up with a precisely similar conceptualization. As long as the other researchers' conclusions are not inconsistent with the original account, differences in the reports would not generally raise serious questions related to validity. (Schofield, 1990, p. 203)

Data analysis

This chapter has described the methods used to collect data which can help to provide answers to the research questions of the study. Data from all sources—the transcripts of program use, the interviews with students, interviews with supervising teachers and other documentary evidence and notes—were analysed using techniques of qualitative analysis recommended by Miles and Huberman (1994), Eisner (1991) and McCracken (1988). The analysis of this data, together with discussion of the findings are given in the next four chapters.

Multimedia analysis and discussion

Interactive multimedia is a relatively new educational innovation in primary, secondary and tertiary level classrooms. While the educational community has enthusiastically embraced its potential, relatively little is known about how students learn from multimedia, and the design features that promote effective learning.

This chapter provides analysis and discussion on the use of interactive multimedia incorporating design features based on a situated learning model. Chapter 3 outlined the features critical to a situated learning model and Chapter 4 described the development of a learning environment based on those critical features. Chapter 5 described the implementation of the situated learning environment with a group of preservice mathematics teachers in the second year of their degree, and the collection of data to enable the research questions to be answered. This chapter presents the analysis of data relating to the first research question. It begins with a description of the process of data analysis and concludes with a discussion of findings.

Research question 1

How do students use an interactive multimedia program designed to incorporate the characteristics of a situated learning environment?

Framework and method of analysis

Techniques of qualitative analysis recommended by Miles and Huberman (1994), Eisner (1991) and McCracken (1988) were used to analyse the data collected from the interviews with students, the transcripts of observation of program use, interviews with supervising teachers and other documentary evidence and notes. Data collected from both the pilot study and the main study were considered. The analysis involved the three step process proposed by Miles and Huberman: data reduction, data display, and conclusion drawing and verification. The analysis was done with the assistance of NUD•IST (Qualitative Solutions & Research, 1993), a computer-based qualitative analysis program. The process of coding data in several stages was

conducted in a manner similar to that described by McCracken (1988). McCracken's stages were recommended for use with a word processor. However, the NUD•IST program has a number of powerful and dedicated functions which ensure an even more efficient categorisation and presentation of data than is possible with a word processor. The process of coding the data on the computer is summarised below in Table 6.1, together with Miles and Huberman's stages, McCracken's stages, and the computer software used.

Table 6.1: Stages of computer analysis of data

Description of process used to analyse data	Miles & Huberman's (1994) stage	McCracken's (1988) stage	Software used
Transcribing: Interview and observation data transcribed for analysis.			Microsoft Word
Coding: Individual comments coded according to *a priori* categories determined by the research questions, such as, *authentic context, multiple perspectives* etc., and categories which emerged from the data. Each category comprises a node.	**Data reduction**: Selection, focusing, simplifying, abstracting and transforming the data.	**Stage 1**: Judgement of individual utterances with little concern for their larger significance	NUD•IST
Sub-coding: Each node, e.g., collaboration, was investigated in more detail to reveal the themes and issues which emerge. Sub categories were determined and nominated as new nodes.		**Stage 2**: Meta-observations where implications and possibilities of the data are examined more fully.	NUD•IST
Ordering and displaying: Patterns and themes were determined, and generalisations made. Data is organised into displays when appropriate.	**Data display:** Creation of organized, compressed assembly of information that permits conclusion drawing and action.	**Stage 3:** Observations are developed in relation to other observations.	Microsoft Word
Conclusion drawing: Conclusions were made and written up for inclusion in the thesis.	**Conclusion drawing and verification**: Decisions about the meaning of data and testing validity of findings (pp 10-11).	**Stage 4**: Judgement of data and analysis, and identification of themes and their interrelationships.	Microsoft Word
Verifying: Conclusions were verified by reference back to original data and review.		**Stage 5**: Review of the four stage conclusions (pp. 44-46)	

This process of analysis of data was repeated for each of the research questions. In writing up the discussion of the findings, the following advice of Eisner (1991) was followed:

> No narrative that seeks to portray life experience can be identical to the experience itself; editing, emphasizing, and neglecting through selection are ineluctably at play. Hence, we seek not a mirror but a tale, a revelation, or a portrayal of what we think is important to say about what we have come to know. This narrative should be supported by evidence, structurally corroborated and coherent, but it cannot be a disembodied listing of what somebody did or saw. It needs both a cast and a plot; it needs to have a point. (p. 190)

Analysis of data

In Chapter 3, a list of guidelines was formulated which specified the characteristics of a situated learning environment, and how these characteristics might be operationalised into the design of the interactive multimedia on assessment (Table 3.13). Some of these guidelines impacted on the implementation of the program in the classroom, but others directly guided the design of the interactive multimedia program itself. The most relevant guidelines for the design of the multimedia software were that the program needed to provide:

- a physical environment which reflects the way the knowledge will ultimately be used (Brown, et al., 1989b; Collins, 1988; Young & McNeese, 1993)

- a non-linear design to preserve the complexity of the real-life setting (Brown, et al., 1989b; Collins, 1988; Young & McNeese, 1993)

- a large number of resources to enable sustained examination from a number of different perspectives (Spiro, et al., 1987; Young & McNeese, 1993; Brown, et al., 1989b; Collins, 1988).

All of these principles were manifested in the interactive multimedia program in the design of the interface, the presentation of the media elements and in the means of navigation (Table 4.2).

From a 'cross-case' analysis (as opposed to a case-study analysis, cf., Patton, 1990) of the transcripts of the interviews and students' talk as they used the interactive multimedia program (data from the 2 students in the pilot study and 6 students in the main study), themes and trends emerged which began to illuminate the subject of how they used the interactive multimedia program which incorporated the characteristics of

a situated learning environment. Two or three of these themes (such as *Navigation* and *Interface*) were based on specific questions in the interview schedule (Table 5.4) and were anticipated as *a priori* categories for NUD•IST analysis; others emerged from the data analysis. Each of these themes—*History of use, Technology as magic, Interface, Navigation, Search strategies*, and *Use of time*—is discussed in detail below.

History of interactive multimedia use

The students' history of interactive multimedia use prior to the use of the assessment program was limited. Several had used computer-based games and other programs at home but there had been little use of multimedia in their academic program either at school or at university. The use of multimedia by each student in both the pilot and the main study is summarised in Table 6.2.

Table 6.2:   History of IMM use by participants in the study

Name of student	Non academic IMM use	Academic IMM use
Debra	Interactive books for children and encyclopaedias 'I've used a couple, especially the interactive books ... through my cousins, who have them for their kids. We've just bought a computer at home, so we've got all the encyclopaedias and things ... they've got interactive games on them.'	Little academic use 'I suppose there's the CD-ROM in the library' [bibliographic data bases]
Glen	Mainly games 'I've played some games, Windows 95 and things ... Dune 2, Civilization'	Use of IMM in classroom 'Last semester in our maths and computing unit we had a bit of a look at interactive story books ... *Grandma and me, Arthur's teacher trouble, the Magic school bus.*'
Evie	None	None
Louise	Little non-academic use 'No, not really'	Little academic use 'Just the CD-ROMs from the library' [bibliographic data bases]
Rowan	Limited 'One or two at home ... the sort of interactive ones that teach you how to use your computer'	No academic use
Carlo	Mainly games 'Just all sorts of things ... playing games'	Computer-based exercises 'The only thing I have seen is that OR operation and that is pretty laid back'
Zoe	None	None
David	One non-academic use 'I can't remember what it was'	None

The assessment program was designed for novice users of computers: computer experience was not a prerequisite for use. Few of the students had significant exposure to computers or multimedia programs and this did not appear to impede their effective use of the program. One student's comment sums up this belief:

> I haven't had experience with anything else so I can't really compare it ... we were all straight into it so it can't be too difficult. And we haven't had much instruction ... it is pretty self explanatory. (Interview with Carlo)

Technology as magic

Arthur C. Clarke (1973) in his book *Profiles of the future: An inquiry into the limits of the possible*, described advanced technology as 'indistinguishable from magic' (p. 39). Others have repeated this theme in relation to interactive multimedia where many refer to its 'magical qualities' (e.g., Morrison, 1994). For example, John Sculley, Chief Executive of Apple Computer, Inc., in 1988 described the potential of multimedia learning environments:

> Teachers and students will command a rich learning environment that, had you described it to me when I was at school, would have seemed entirely magical ... Imagine a screen that can display in vivid colour the inner workings of a cell, the births and deaths of stars, the clashes of armies, and the triumphs of art. And then imagine that you have access to all of this and more by exerting little more effort than simply asking for it to appear. It seems like magic, even today. (Sculley, 1988, p. vii)

The active nature of learning, the multitude of choice and the ease of access attributed to interactive multimedia by Sculley, are all mirrored in the following comment from one of the students:

> Oh I liked it, it was much more interesting than sitting in a classroom listening to a lecturer because you choose your own information that you want to know, and you're actually doing it. And it is easy, like you don't have to look around the library for everything that you want. It was all there for you. (Interview with Louise)

The sense of magic and amazement at what the students were able to do was also evident. They had not been sufficiently exposed to multimedia to lose that sense of wonder and excitement that is to be found in the use of a new technology. For example, one student expressed wonderment at the capabilities of computers:

> It's just so amazing what computers can do, and how things are done. (Interview with Debra)

Another student referred to the program as something children would have fun with, expressing his own childlike sense of fun:

> It was something different to start off with, not just the boring handout or something ... it made a lot of sense and it was good to play around. Sort of things ... kids would have fun with. (Interview with Rowan)

The spontaneous amazement and delight of one student was obvious when he realised the scope and extent of the multimedia resource as he used the program:

> Mega! So this is a massive, massive database. (Observation of Carlo using multimedia program)

In discussing the positive aspects of the assessment program, students frequently mentioned its motivational ability. Generally, they attributed the motivational power of the learning environment to four aspects. Firstly, many students felt that the fact that they could work at their own pace was motivating. They made frequent references to the alternative scenario, such as, 'not just the same old boring thing', comparing the more restricted lecture-based approach to the freedom the assessment program allowed. Secondly, several students mentioned the motivating influence of the partner working in the small collaborative groups. For example, one student mentioned that his partner kept him motivated by keeping him on task. A third motivating influence mentioned by one student was the authentic assessment of the task, both for its intrinsic interest and the fact that it was being graded. Fourthly, many students mentioned the inherent motivation of computer-based learning, although this was qualified in many instances. For example, one student hinted that the motivating power of a computer was in its novelty:

> I have never seen anything set up like that before so it was interesting, yes so that was pretty motivating. I think the thing that we'd never done it before, and it's not going to go on for the whole of semester ... I don't think you can learn everything on a computer, so I think that was why it was most motivating cause we'd never done it before. (Interview with Zoe)

Other students were more wholehearted in their endorsement of computer-based learning, for example, the following comment was typical of these positive comments:

> I find anything on the computer quite motivating. (Interview with Evie)

The students frequently mentioned the word *fun* in their descriptions of the use of the assessment program, not as they were using the programs, but in their reflective responses to the interview questions. One might suspect, however that the fun might more usefully described, as it was by a young student working on a LEGO/Logo problem, as 'hard fun' (Negroponte, 1995, p. 196). The students made comments such as the following:

> It was fun, it was something different. (Interview with Rowan)
>
> It was a different approach, it was fun. (Interview with Evie)

> It is fun, it's more fun, it gets you a bit more into it. (Interview with Carlo)

> It was set up in a fun way. (Interview with Debra)

However, this positive response to the motivating magic of the interactive multimedia experienced by the students was countered by feelings of annoyance in dealing with technical problems, described by Clifford Stoll as 'the computer's universal ability to generate frustration' (Stoll, 1995, p. 60). Stoll and others (e.g. Cuban, 1996; Postman, 1992; Spillane, 1997; Slattery, 1995) have been vocal in pointing out the shortcomings of computers in learning environments. They argue that, despite the sometimes exaggerated claims made for the potential of computers, traditional methods such as print, pencils, paper and the post, are often faster, more efficient and more economical than the computer-based alternatives. None of the technical problems experienced by the students was severe enough to impede their effective use of the resource, but they clearly caused annoyance and frustration, and distracted them from the task. Some of these annoyances related to the program itself:

> If we were watching the video and we found something important, and we clicked into the notebook, and then the video wasn't in any more. Like we would pause so we still wanted it to be same position but we'd have to start it all again. Yes, so that was a bit annoying. (Interview with Zoe)

Some problems were possibly caused by a computer in the laboratory not meeting the minimum requirements specified to run the software. For example, some of the video clips were very jerky or did not run while the soundtrack continued to play:

> And the video, you'd hear the voice over but it looked like the video was dragging, like not connecting. And on some of them we couldn't even hear the audio. It kept on cutting out. Just little things like that, that was the only thing that really made it a bit harder for us. (Interview with Louise)

Other frustrations were caused by the sheer unpredictability of computer technology, the myriad of unexplained happenings which conspire to defeat the human users, such as system crashes, disappearing desktop icons and disks refusing to eject. Apart from the expletives occasionally detected on the recordings as students used the program, this kind of frustration was summed up by a student in the following comment:

> Ours had a few glitches and that was really annoying. And just basically computer problems, like our mouse wouldn't work, and the disk wouldn't save. (Interview with Louise)

In dealing with computer technology, students experienced both the motivating, magical wonderment that advanced technology can provide, as well as the inevitable

frustrations that plague every computer user. It is possible that with future use, both will move from the extremities of the continuum: with regular use, students will take for granted the capabilities of the technology and no longer marvel at the magical qualities of multimedia; and computer technology will improve to the point where technical problems become fewer and more manageable.

Interface

The user interface of the interactive multimedia program on assessment was designed to reflect the real life context of a classroom. The design and development of the interface was described in detail in Chapter 4. An ecological or intuitive interface design (i.e., objects within a context) was favoured over a lexical design (i.e., words on buttons) as it was more in keeping with the situated learning characteristics upon which the program was modelled. Such an interface can quickly become intuitive in its use as there is no need for the processing of the labels on buttons to intervene in the action of retrieving the information (Hedberg & Harper, 1996; Pejtersen, 1993). Negroponte (1995), in his discussion of the 'secret to interface design' writes:

> When you meet somebody for the first time, you may be very conscious of their looks, speech and gestures. But quickly, the content of your communication dominates, even if it is largely expressed through tone of voice or the language of facial expressions. A good computer interface should behave similarly. (pp. 93-94)

Students responded positively to the interface. They appreciated the classroom context, and there was no hint that they felt patronised by pictures rather than words. The following comment indicates that this student was very aware of the difference between the ecological interface employed by the assessment program, and the alternative lexical design:

> It was set up in a fun way, like it was a classroom. You had your video sitting there, you didn't just have the word 'video' and it didn't have the word 'filing cabinet' there. It was all there with pictures and you could relate it all. (Interview with Debra)

Another described a similar button-based interface design in the following comment, suggesting that he had been exposed to this design before, and interestingly, equated it with the traditional method of university teaching from the blackboard:

> The last thing you want is ... a screen you scroll down, then it gives you the heading of whatever subject it is and a description, and maybe it could have a 'Press play' for the videos. It's just looking at a boring computer screen. You could do that straight off the [black]board. What's the difference? (Interview with Rowan)

Sound effects were used in the program to provide instant feedback to students that the choice they had selected had been effected. For example, clicking on a filing cabinet drawer gave a squeak as the drawer opened before the document 'in the drawer' appeared on the full screen. Students responded favourably to this feature as well:

> One thing I will always remember. I went to open the filing cabinet and it squeaked. That was excellent ... the first time I heard it, you know, I nearly laughed my head off. (Interview with Rowan)

Students generally found the interface was logical in its layout and very easy to use. The students appeared to conceptualise the layout of the various resources and their contents very quickly. One student mentioned that you always knew where to find things. Another compared the simplicity of the ecological interface favourably with the verbal nature of the Internet, and that he could just click on what he wanted without having to search (this point is discussed more fully in the section entitled *Navigation*).

The one feature almost all the students disliked about the program was the size of the video picture. All the video clips appeared in the area given to the television screen, a space with dimensions of approximately 5cm by 4cm. The size was limited by technical constraints and the limited memory capacity of CD-ROMs, an important consideration when dealing with memory-intensive files such as Quicktime video files. Some students mentioned that they would have preferred the picture to be much bigger. Norman (1993) points out that larger screen size enables viewers to be 'captured by the event' and 'sensory experience is maximized' (p. 34). One student mentioned that the limited size of the video was compensated to some degree by the ability to scrutinise the unreadable documents shown on the video from another source, in this case, the samples drawer:

> With the video it would be good if it could zoom up to a full page ... but it was OK. When they [the camera angles] were over the shoulder, [showing] marking or something, they showed the work but we couldn't see it, which was good for the samples bit. We could go into the samples drawer and have a look, so that was a great bit. (Interview with Debra)

One interesting trend which emerged from the interviews (and this is reflected in the quite considerable literature on 'designers as learners', cf., Jonassen & Reeves, 1996) was the students' enthusiasm for suggesting what *could* have been done with the

interface. One student, made the point that the size of the video screen, while suitable for tertiary students, would have to be made bigger for younger children. In so doing he was not discussing how he found the program's interface, but had moved into general interface design considerations from the perspective of a potential user group. Another student suggested that there should have been an apple sitting on the desk. When questioned what the apple might do if it was clicked, the student became quite excited about the possibilities:

> Say 'Take a lunch break'. Or when they'd had enough [time working on the program], you could have a worm come out. (Interview with Zoe)

Similarly, David felt that the notebook should have been instantly accessible at all times, and proposed an interface design which would have allowed it:

> I actually do think a good idea would have been to split the screen to have the notebook one side, and what you are reading or watching on the other. So you could just like cut and paste. (Interview with David)

Generally, students adapted very quickly to the layout of the interface, and found the resources easy to access and use. The only feature students disliked about the interface was the inability to make the video pictures bigger. Future advances in computer technology will inevitably enable this facility, however, the limitations pertinent at the time of development restrained the image size for the program.

Navigation

The organisation of information and material in multimedia programs can vary significantly. At one end of the continuum, material is presented sequentially, in a linear fashion, where students' choice of movement is limited to going forward or backward. At the other end of the continuum, students have unlimited choice in accessing material (see Figure 6.1).
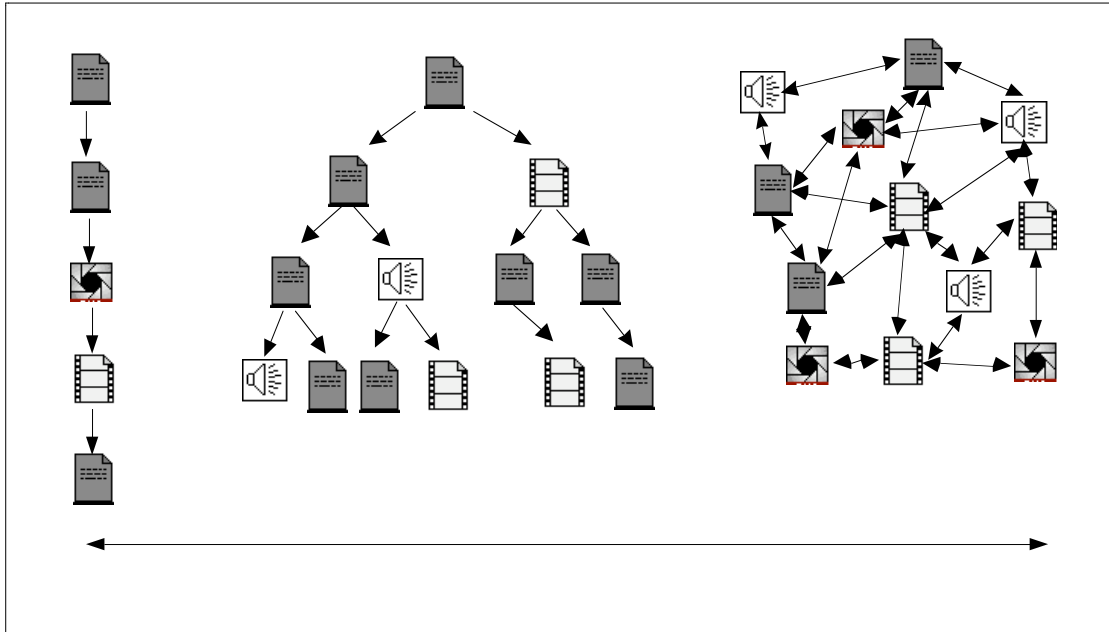
Figure 6.1: Continuum of multimedia organisation (Oliver & Herrington, 1995)

Navigation systems are provided in interactive multimedia programs to enable the user to move around and investigate the resource. The purpose of navigation tools within a multimedia program is to: locate and access particular information or instructional nodes, purposefully move between related information or instructional nodes, to establish one's current position within the information or instructional base, and to return to known reference points (Oliver & Herrington, 1995).

The suggestion has been made that in order to accommodate different levels of ability, interest, and metacognitive skills, the design of interactive multimedia courseware could incorporate a default linear navigation pathway from which learners can, with experience, move to a more flexible hypermedia navigation of the program (Putt, Henderson, & Patching, 1996). Such a design implies a single interpretation of the material is possible. It was inconceivable for the assessment program to be presented in a linear format, even as a support mechanism for beginners. Rather, the program was designed to provide referential linking to enable students to readily access any media element or document, together with the notebook and the help screen. All elements are accessible from the main interface, and all clickable objects lead only to a single branch, that is, no submenus appear when objects are clicked. (The exception to this is in the notebook, where students are given a list of investigation topics when they click on the *Investigations* tab.)

The assessment program uses very simple navigational devices to enable the users to investigate the resource. The main classroom interface enables direct access to

individual documents and video clips within a single strategy. Each strategy can be selected by an indexing system provided on the whiteboard in the main interface. Generally, students had very little trouble acquainting themselves with the navigational systems provided by the program, and they readily accomplished the means to investigate the resources. A typical comment was one such as this:

> It was just so simple to use because it's all there ... there's a clear way to get back to it. You don't feel like you're getting lost. (Interview with Debra)

Typically, the navigation strategies employed by students as they used the program (as observed on the videotapes) were these:

1. Students would select an assessment strategy from the index on the whiteboard and investigate one or more media elements related to the strategy

2. To move back to the main interface from any individual item, students would click on a small main-interface icon at the bottom of the screen

3. To move to the notebook from any screen in the program, students would click on the notebook on the desk in the main interface, or click on the notebook icon from any of the individual items.

The students appreciated the non-linear layout of the program from a navigational perspective. The freedom to access material in the order of their own choosing was commented on by a number of students. For example, this student noted that the program did not force the user to complete elements of the program in sequence:

> You could go through and do whatever you like. It doesn't say you have to do this bit first, and then that bit. You could go and do whatever. (Interview with Debra)

One student compared the navigation of the assessment program to a more linear structure he had experienced in another computer-based program:

> You can't get lost in it like some programs, you know if you go into this and you go into that, then to that. When you want to go back out it is a bit rough ... To go back you have to like go back eighteen pages, and you have to go back another five, forward another eighteen pages. (Interview with Carlo)

Some students also commented on the fact that the notebook could be accessed from any point in the program and that this complemented the non-linear nature of the package. The following comment by a student implies that the ease of access of the notebook facilitated his ability to reflect as he used the program:

> I liked being able to do things at my speed, and I like the notebook, being able to flip to the notebook from anywhere, and being able to jot down what you're thinking. (Interview with Glen)

Knowing where to look without the fear of getting lost was obviously an important consideration in the students' use of the program, and the straightforward nature of the program was compared to information-seeking on the Internet. The comment by this student indicates frustration with searching in a labyrinth:

> It was very well set out and you didn't have to go looking for things like when you're 'netting', you have to go, 'Well it might be in here, or here', and you look in there, so it leads to something else and you have to go back where you started. (Interview with Glen)

Methods of tracking progress in hypermedia environments have been likened to the mythical Theseus who laid a thread to retrace his journey through the maze of passages in the Labyrinth of Daedalus (Harnden & Stringer, 1993; Stringer, 1992). The students' comments on the navigational ease of the assessment program indicates that no retracing aid is needed. The navigational systems in the assessment program provide students with a relatively flexible, referential system where any node of information is accessible within two clicks of the mouse. One student described the simplicity of the navigation process:

> It's just the fact that you can reflect as well, you can go back. And once you have seen one video you think 'What did they say in that one back there?' Click, back up to the top and have a look. And it's all quick as well. Like it's not a long process where you've forgotten what you're after. It's still in your head. You're thinking 'Oh yes, oh yes, fair enough' and it's upwards and back. You can do it and go back and then go back to your notebook and make notes. (Interview with Carlo)

The means of navigation used by the students as they worked with the interactive multimedia program on assessment was generally found to be comparatively simple and effortless. Students had little difficulty finding what they were looking for, and were quickly able to return to the main interface without having to follow links through several layers of materials with the possibility of not finding their way back.

Search strategies

In order to complete the task, students used navigation strategies to access the various media elements and to search through the materials in a purposeful manner. An audit

trail (Schwier & Misanchuk, 1993) was made from data provided on the videotapes to determine the manner in which the groups accessed the material.

Search strategies employed by students varied considerably between groups. Students could choose to approach the search systematically, or use an unstructured path through the program. All the groups approached the task systematically opting either to investigate the resource by *strategy* (the assessment strategies written on the whiteboard in the interface) or by *media element* (the video clips or the documents in the filing cabinet).

Interestingly, each group used a different search path to examine the materials and purposefully seek information. Three initial steps, however, were common to all groups at the beginning of their use of the program. Firstly, they used an initial orientation strategy where the students moved almost randomly around the resource, clicking here and there, trying out elements and determining the scope of the resource. The following statement summarises the approach:

> Firstly we went through, just picked out things of interest to see what the package was about, just to see what it had to offer. We did that with about five different ones, made a few notes on it. Then we decided to go through from the start and work through it that way. But we spent the first five minutes on interest, just seeing what was like, playing around with it to see what it could do. (Interview with Rowan)

Secondly, every group of students returned to examine the task they had been set, either in the electronic form in the notebook, or the hard copy form which they had received as a handout. Students took a few minutes to reassess the task in the light of the scope of the resource; and then thirdly, each group planned an initial strategy, or first move on how they might proceed to begin. For example, Steps 2 and 3 are illustrated in the following excerpt:

Debra:	So are we going to do one from each category? Is that how you want to do it?
Glen:	Not necessarily. Let's just read the question again. (Look at activity for 4 minutes).
Debra:	What does it want us to do?
Glen:	So we have to decide which ones we're going to use and then look at the advantages. It actually just says 'formally request that you prepare a report on alternative approaches to assessment in mathematics to be presented to staff. Right it also says to prepare a suggested plan on how the school might proceed including benefits and problems for parents students and teachers. OK. So what if we put

these two together so you have checklists with space for writing here.
(Observation of group using multimedia program)

After these initial steps, however, each group approached the task using different search strategies. The strategies employed by each group are described in detail below.

Group 1: Debra and Glen

Debra and Glen adopted a systematic, but selective approach to searching the assessment program to prepare their report. They investigated all the *Descriptions* of strategies in the top drawer of the filing cabinet (a media element) to get an overview of the different assessment techniques, then explored other media elements selectively:

> Basically, we went through all the descriptions to get an overview of what the strategies were, and how they were implemented. And then we went through and picked the ones that we thought sounded good or would be valuable in the classroom, then we looked further into them, like into the things in the filing cabinet. Sometimes we looked at all of them, and sometimes we just looked at a couple of bits. (Interview with Glen)

This appeared to be an unusual search method, as it meant that the students looked at the majority of text *Descriptions*, which took a considerable period of time, before they watched the demonstrations of each assessment strategy in the *Scenarios*. However, Debra felt that the *Description* section was almost mandatory reading to begin the investigation of each strategy because none of the other elements gave complete information about what the strategy was. For example, the *Scenario* video of the teacher using a checklist in the classroom was simply a scene of a teacher observing students and making notes on a pad. Without the description, it would have been difficult, at first, to ascertain what the assessment strategy was. The same student described a similar problem with some of the documents:

> You need to get that information first because otherwise you wouldn't know what they're talking about. Like in the reflections they don't actually say 'A checklist is ...' They say 'I use checklists and I found it to be ...'. They don't actually say what it is (Interview with Debra)

The context of the search and its purpose was also an important consideration to this group in the way they approached the search. Debra was careful to point out that the search strategy employed was specific to the particular task they had been given, not necessarily to their own style of using interactive multimedia programs:

> So we went through it that way, purely because of the question we had. If it was a different question we probably would have tackled it a different way, but because of the question we did it that way. (Interview with Debra)

The search strategy employed by the students in this group is summarised in the flow chart below (see Figure 6.2).
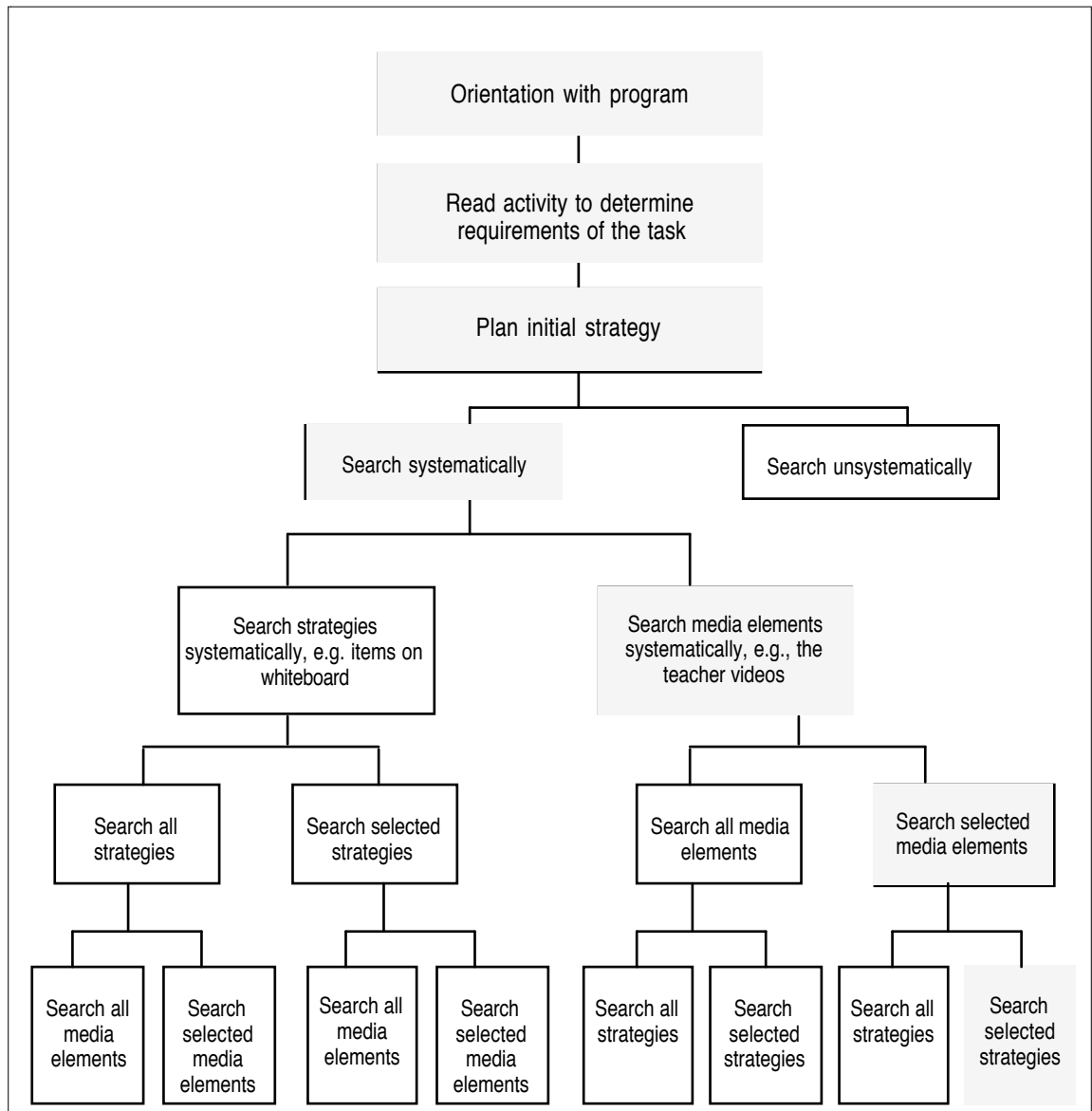
Figure 6.2:   Search strategy employed by Group 1 - Debra and Glen

Group 2: Louise and Evie

The search strategy employed by Louise and Evie differed from that of Debra and Glen. This group employed a systematic search which began by selecting assessment

strategies at the top of the whiteboard and working down through the entire list. Once inside a particular strategy the students usually viewed the *Scenario* video first, followed by the other two videos. They then moved to the top of the filing cabinet and worked their way down, although as they became more accustomed to working with the resource, they became more selective in the elements they accessed. The search strategy employed by the Louise and Evie is shown in the flow chart in Figure 6.3.
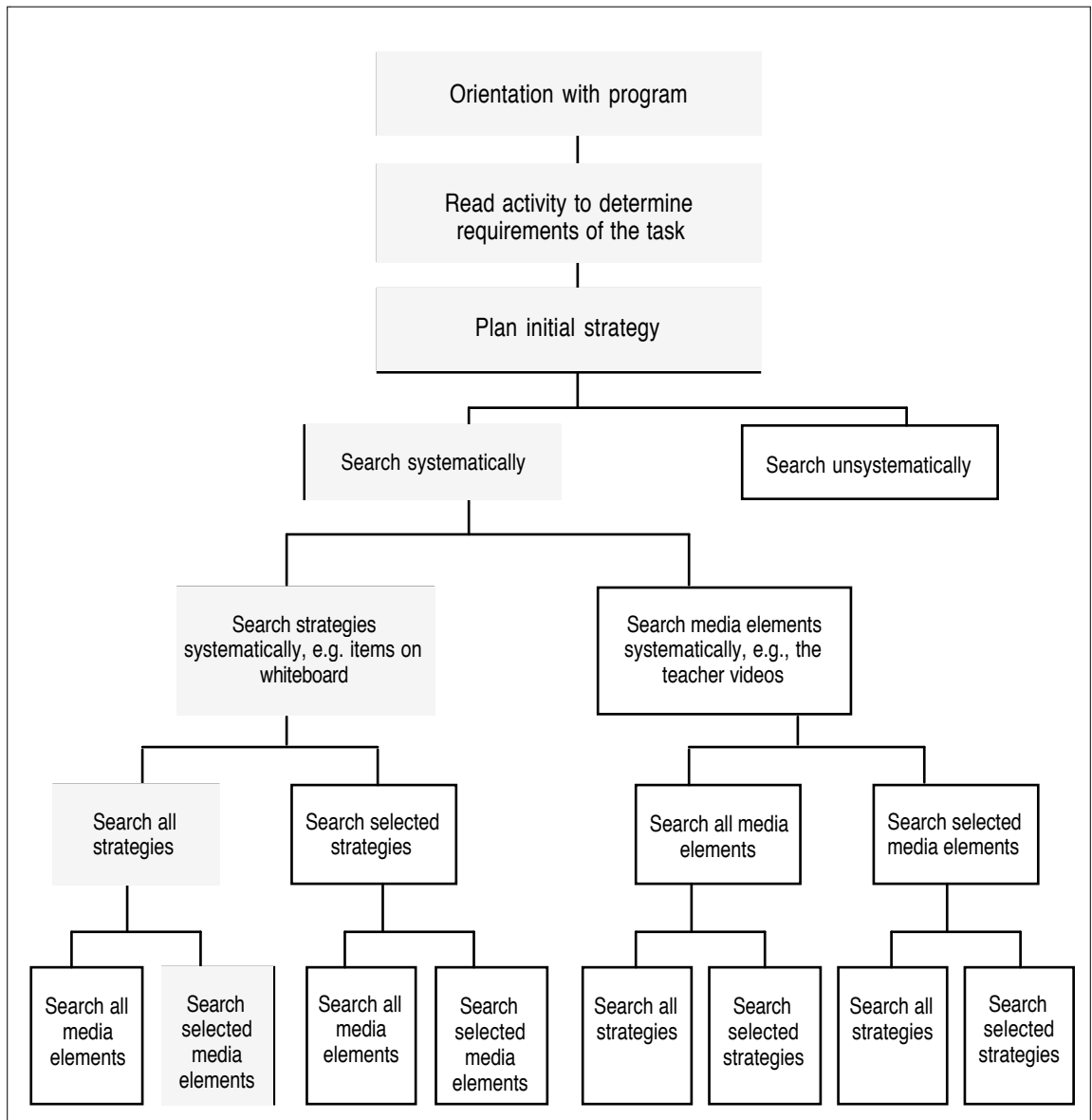
Figure 6.3: Search strategy employed by Louise and Evie

Group 3: Rowan and Carlo

Rowan and Carlo were the most selective of all the groups in their choices of both the strategies and media elements to investigate. They did not look at every assessment strategy on the white board but selected the ones that appeared to most relevant, or in their words 'if it sounded really good'. Once in a strategy, they generally looked at the *Descriptions* and *Samples*, then the three videos, although this too varied with the strategies. The *Reflections* and *Interview* drawers were accessed sporadically 'depending on what we thought about it'. The search strategy employed by the Rowan and Carlo is shown in the flow chart below (see Figure 6.4).
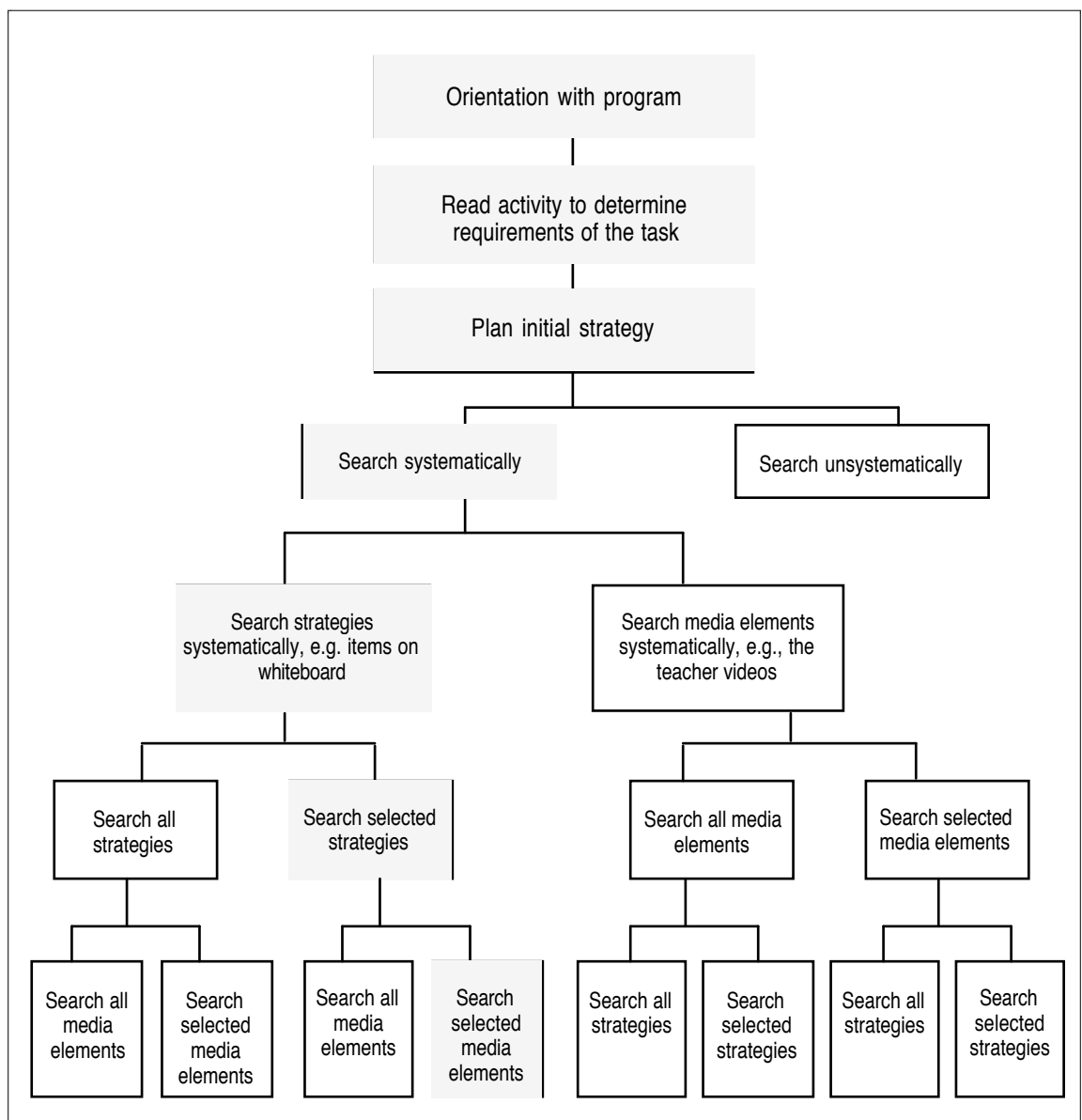
Figure 6.4:   Search strategy employed by Rowan and Carlo

Group 4: Zoe and David

The most comprehensive approach to searching the resource was adopted by Group 4: Zoe and David. This pair generally worked their way through the strategies on the whiteboard by beginning at the top and working their way down. Once in a strategy they worked their way through the filing cabinet drawers, then through the videos. As Zoe explained: 'We wanted to have the background so we'd know what was going on [in the Scenario]'. The search strategy employed by Zoe and David is shown in the flow chart below (see Figure 6.5).
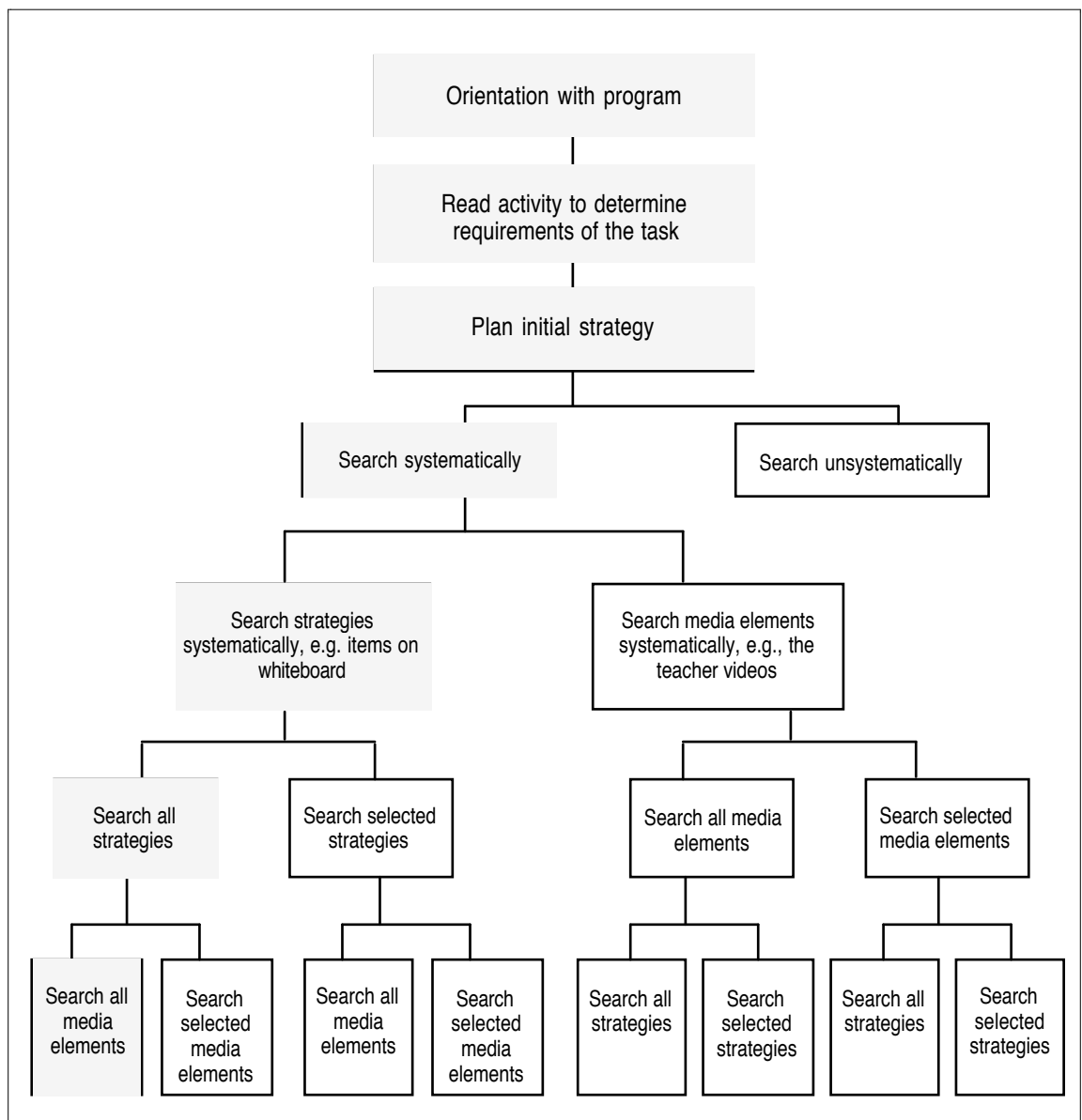
Figure 6.5: Search strategy employed by Zoe and David

The interesting thing to note about the search strategies employed by the four groups is how certain elements of the search, particularly at the beginning, were identical. However, once involved in the investigation of the resource to complete their reports, each search took a different route. The similarities include the initial orientation with the resource, and the returning to the task to examine its requirements before selecting an approach for searching the resource. The differences are that each group agreed upon a different method of searching through the assessment strategies and the media elements within each strategy. It was thought that the list of strategies on the whiteboard in the main interface might prompt students to simply follow the order of strategies and to then move systematically through the media elements, through all the filing cabinet drawers and all the videos. While this was the approach adopted by Group 4, the other groups chose to use the whiteboard listing more flexibly. Such a finding endorses the referential navigation system incorporated within the interactive multimedia program, and enables each group using the resource to create individual search strategies best suited to the needs of their own unique response to the investigation.

Use of time

The allocation of time to different student activities in formal university settings, has been investigated by Laurillard (1996). In a study of the distribution of time devoted to a variety of learning activities, Laurillard found that 'attending' was by far the most common activity. As an example, she gives the distribution of activities of a student in an engineering course in a 40 hour study week (Table 6.3).

Table 6.3:   Distribution of student activities in a 40-hour study week (Laurillard, 1996)

	Attending	Practising	Discussing	Articulating
Lectures	15			
Audio-visual	1			
Tutorials	3		1	
Practice		10		
Reading	2			
Assignments				8
TOTAL	21	10	1	8
	52%	25%	3%	20%

While these figures appear to allow for enormous latitude—for example, they assume that no discussion occurs in lectures, that no attending occurs in assignments, that no discussion occurs in audio-visual—they indicate that traditional methods of teaching at university emphasise the transmission of knowledge rather than active participation by students in the learning process.

By contrast, anyone who has observed a child playing on a video arcade or Sega/Nintendo game will have noticed that the child has a very active role. However, there is very little time for the child to think in responding to the various challenges presented by the life-and-death situations. Children react rather than consider. For many of these programs, the educational value for the player is inversely proportional to the reaction time required (ASCILITE, 1995).

Both of these situations point to possible shortcomings in learning environments: the first in denying students an active role, the second, in denying a reflective role. The Cognition and Technology Group at Vanderbilt (1992) make the point that the learning environments they produce are meant to be explored and discussed at length rather than simply read or watched. Similarly, the interactive multimedia program on assessment was designed to minimise keyboard responses, and maximise thoughtful, active reflection and discussion between the users. In the videotaped sessions, it was noticed that students use of the keyboard was relatively infrequent. Most of the time appeared to be spent thinking and discussing. In order to substantiate this observation on the amount of time spent on various activities, one group of students was monitored using the program for a period of exactly 30 minutes, starting approximately 30 minutes into the students' second work session. This was done to allow a short settling in period in order to gauge a more typical pattern of use. The students' actions were timed according to the following four categories:

1. *Attending*: Selecting, watching or reading the media elements of the assessment program such as the video clips or the expert comments

2. *Discussing*: Discussion between partners or reflective thinking (silence)

3. *Typing and composing*: Typing reflections and responses in the notebook and formulating what to type

4. *Off task*: Off-task behaviours.

These categories most closely resembled the observable types of behaviour that were of interest, and were more salient than the categories chosen by Laurillard (1996).

Laurillard's distinction between discussion and articulation was particularly problematic given the theoretical framework described earlier in Chapter 3.

The data was analysed using the beta version of *VideoSearch* (Knibb, 1997), a software program which facilitates analysis of qualitative data by coding excerpts of videotaped material into user-defined categories. The program is similar to NUD•IST (Qualitative Solutions & Research, 1993) in that it enables analysis of qualitative data, but where NUD•IST works with text in the form of transcripts, *VideoSearch* works directly with the video data. The program enables coding from a digitised video source by selecting a segment of the video and attaching it to one of the categories. Figure 6.6 shows the coding tool with the four defined categories of activities on the left hand side. The video movie on the left is the digitised video source of 30 minutes of students' use of the multimedia program on assessment. The video clip on the right is the selected video clip, the eleventh occurrence of *Discussing*.
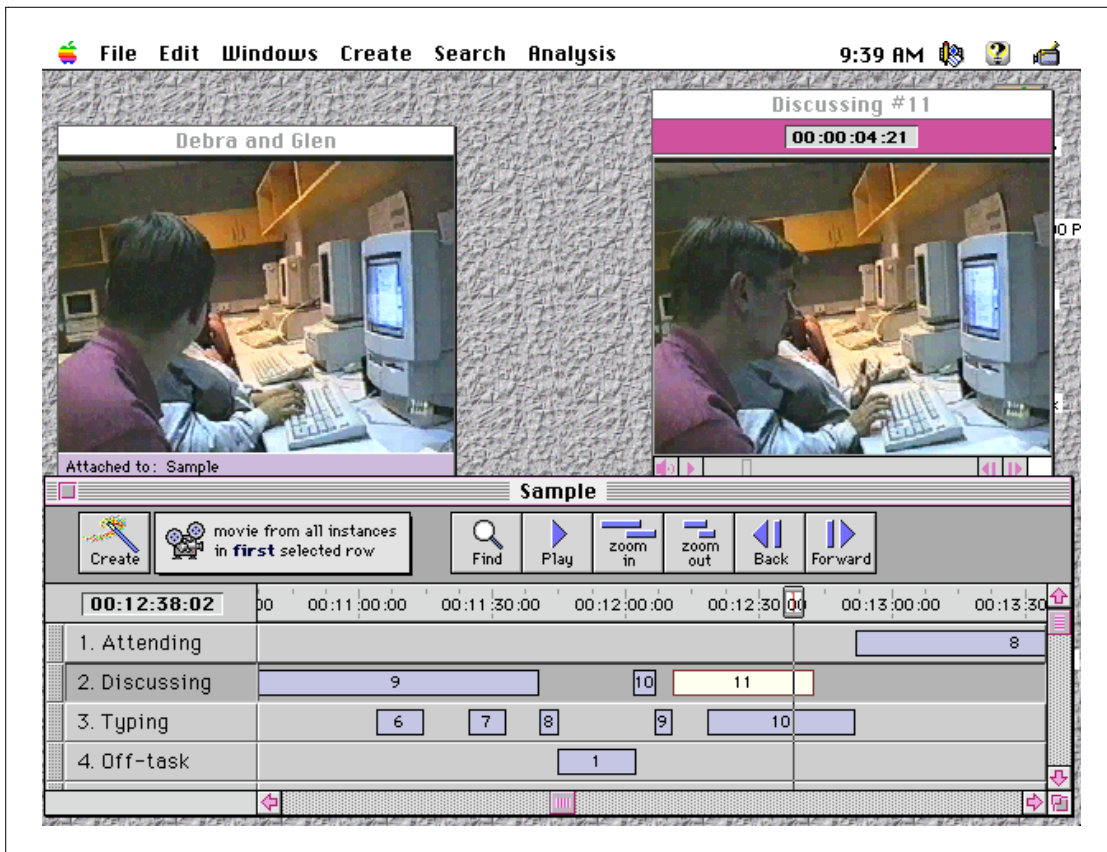
Figure 6.6:   The VideoSearch interface showing the data as coded (bottom), the digitised video source (top left) and a categorised excerpt (top right)

The *VideoSearch* software enabled a very precise categorisation of student activity. On occasions, the students engaged in two activities at the same time, for instance, discussing, and typing, where while one student typed the other's talk was on general issues rather than the composition of what to type. On these occasions, the instances of both were recorded, such as excerpt No. 11 of *Discussing* and excerpt No. 10 of *Typing* in Figure 6.6 above. This meant that while 30 minutes was monitored, the total time amounted to 34 minutes and 3 seconds. Percentage times were calculated from the total of combined activities. The times recorded on each of the four nominated categories are provided in Table 6.4 below.

Table 6.4:   Percentage times spent on student activities while using the assessment program

	Attending, selecting, watching reading	Discussing, reflecting	Composing and typing in notebook	Off task
Total time	11 mins 7 secs	15 mins 41 secs	6 mins 51 secs	24 sec
Percentage	33%	46%	20%	1%

The figures suggest that the assessment program is conducive to promoting student activities other than attending behaviour. Unlike the traditional university courses mentioned by Laurillard (1996) and McNaught (1996), with their emphasis on the transmission mode, the students using the assessment program were able to reflect and discuss their learning for a substantial portion of the available time. Their experience was not akin to the student attending in a formal lecture, nor the child reacting spontaneously to a video game. The students attended to the video and text elements provided by the program, and consolidated this information with thoughtful discussion and creativity in the preparation of a written response.

The advent of *VideoSearch*, a powerful tool for analysis of video data, will enable further research opportunities in the investigation of the way students learn from multimedia. Further research is needed to establish precisely the design elements of interactive multimedia which enable reflection and articulation as a paramount consideration rather than a chance event.

Summary

Research question 1 asked: *How do students use an interactive multimedia program designed to incorporate the characteristics of a situated learning environment?* In order to answer this question, an interactive multimedia program on assessment in mathematics was designed to incorporate the characteristics of situated learning as defined in the

literature. Four groups of students were observed and videotaped using the program over a period of 5 hours (one pilot study group and 3 groups in the main study) and their discussion was transcribed for analysis. The analysis of the transcripts and careful viewing of the videotapes suggests that the students used the interactive multimedia program based on situated learning very differently to the way they might use some other types of computer-based resources, such as computer games and the Internet.

Although the students' experience of interactive multimedia use prior to the use of the assessment program was limited, and computer experience was not a pre-requisite for use, they were able to freely navigate the resource to access the media elements. The students experienced a sense of magic and amazement at what they were able to do with the program and many expressed an almost childlike sense of fun. Many students found the learning environment motivating and they attributed this to four aspects: they could work at their own pace, they worked with a partner, the authentic assessment of the task, and the novelty of computer-based learning. However, as well as the positive aspects of the program, students also expressed feelings of annoyance in dealing with technical problems, which clearly caused frustration and distracted them from the task. Nevertheless, none of the technical problems was severe enough to impede their productive use of the resource.

Students responded very positively to the ecological or intuitive interface design and to the sound effects, which generally provided feedback on the selection of an element. They generally found the interface was logical in its layout and very easy to use, and several expressed the view that you always knew where to find things. All the students disliked one feature of the interface—the size of the video picture, although this was compensated to some degree by the ability to scrutinise documents in other sources, for example, in the *Samples* drawer. Nevertheless, the students were very enthusiastic in making suggestions on what *could* have been done with the interface.

The assessment program uses very simple navigational devices to enable the users to investigate the resource, and the students had very little trouble acquainting themselves with it and using it effectively to investigate the resource. They appreciated the non-linear layout of the program and the freedom to access material in the order of their own choosing. Several students noted that the notebook could be accessed from any point in the program and that this complemented the non-linear nature of the package.

Knowing where to look without the fear of getting lost was identified as a vital consideration in using computer-based resources. The referential navigation system

ensured that any node of information was accessible within two clicks of the mouse, and generally students found it to be comparatively simple and effortless. They were able to return quickly to the main interface without having to follow links through several layers of materials with the possibility of not finding their way back.

Search strategies employed by students varied considerably between groups, although all the groups approached the task systematically rather than randomly, opting either to investigate the resource by *strategy* or by *media element*. Three initial orienting steps were common to all groups. They sought out the scope and depth of the resource by freely sampling elements, they re-established the task before them and then decided upon an initial search strategy. Each group then used a different search path to examine the materials and purposefully seek information.

Students used the program reflectively. They spent a good amount of time attending to the content of the program, but unlike traditional university instruction, proportionally more time was spent reflecting and discussing issues with their partners, and composing their response. They enjoyed using the program and valued the choice and self-control it allowed in their learning about assessment.

These findings suggest that the use of the situated learning model was successful in providing guidelines for the development of a interactive multimedia program which students enjoyed using, which enabled them to reflect on their learning and which they found easy and intuitive to navigate. None of the problems encountered with the software related to the situated learning foundations of the program but rather to technological inadequacies and difficulties. Inevitably, advances in computer technology will ameliorate these problems.

This chapter has investigated students' use of, and responses to, the interactive multimedia program on assessment. The following chapter looks at the total learning environment, and analyses in detail each of the nine characteristics of the situated learning model, and how the students' responded to these design elements.

Situated learning analysis and discussion

As previously described, nine critical characteristics of a situated learning environment were determined from the literature and incorporated into the design of an interactive multimedia learning environment on assessment. Chapter 6 described the findings of an investigation into how the students used the multimedia software. This chapter looks more deeply into each of the nine characteristics of situated learning: students' awareness of them, how important they are to students, and their beliefs and opinions about the impact of these features on their learning. The chapter begins with reference to the framework for analysis and then discusses the findings related to each of the critical elements of the situated learning model in turn:

- Authentic context
- Authentic activities
- Expert performances
- Multiple perspectives
- Collaboration
- Reflection
- Articulation
- Coaching and scaffolding
- Authentic assessment

Research question 2:

How important to students is each of the critical characteristics of situated learning in the interactive multimedia learning environment?

Framework and method of analysis

As described in Chapter 6, techniques of qualitative analysis recommended by Miles and Huberman (1994), Eisner (1991) and McCracken (1988) were used to analyse the data collected from the main study (6 students) and the pilot study (2 students): the interviews with students, the transcripts of observation of program use, interviews

with supervising teachers and other documentary evidence and notes. The process of coding data was described in detail in Chapter 6, and similar methods were used for the analysis of data related to Research question 2.

The analysis was done with the assistance of NUD•IST (Qualitative Solutions & Research, 1993), a computer-based qualitative analysis program. Data from the transcripts were coded into categories (or nodes) according to their relevance to the nine elements of a situated learning environment. However, these categories were neither static nor mutually exclusive, and analysis of the video transcripts and interviews clearly showed that responses could not be classified discretely and exclusively under an element. While a student might predominantly be describing a response to a particular element, aspects of the response might also relate very closely to another element (Miles & Huberman, 1994). If a response was thought relevant to any element of the situated learning model, it was considered in the discussion of that section, even if it also related to one or more additional elements.

The nine situated learning elements provided nine *a priori* categories for analysis. However, several sub-themes emerged from the data in the analysis of each of these larger categories, described by Patton (1990) as 'indigenous concepts' (p. 390), and these data-driven themes have been included in the relevant sections. Other sub-themes emerged from the literature review described in Chapter 3, and some related to specific questions in the interview schedules. The situated learning elements, and the findings related to each, are discussed in detail in the sections that follow.

Authentic context

The authentic context presented to students using the assessment package was one of a physical and conceptual structure of a classroom which users were free to explore. The various media elements available to the user of the program provided authentic data from a variety of perspectives. Students had access to more than 60 video clips, over 60 text files and over 20 graphic images, as well as a notebook facility to record their own notes. A sufficiently rich and complex knowledge base was necessary to enable students to solve realistic and complex problems.

In analysing the student transcripts, several themes emerged from the data in relation to the program's authentic context, namely the complexity of the context, how the students were involved with the context, the students' perception of real-life and decontextualised learning, and the real-life relevance of the program. Each of these themes is discussed in detail below.

Complexity

The complexity of the program was not something with which students had difficulty. One student recognised that the program comprised a large body of information:

> It gave you like excess of information rather than not enough. (Interview with Zoe)

Generally, however, students did not recognise that they were working in a complex learning environment. They referred to the simplicity of the program, its ease of use, and its logical layout. However, while the interface and navigational paths of the program were deliberately kept as simple as possible, the conceptual nature of the contents was far from simple. This appeared to surprise one student:

> I was actually surprised at how much you can learn from such a simple brief program. There was just so much in there that you could learn from. (Interview with Debra)

One student provided very eloquent support for Honebein, Duffy and Fishman's (1993) contention that it is not necessary to simplify learning environments to enhance learning, and that designing realistic levels of complexity in a learning environment can help to make learning easier. Rowan supported this argument by pointing out that he was learning almost without noticing it:

> It's surprising. It seems you don't think you've learnt a lot, but you do learn a lot from it because ... you're interacting with it. You just don't notice the learning process happening and I think that's where it's good for students because they hate the actual learning process. They hate sitting there and learning whereas if it's something that they don't realise, their learning is good. (Interview with Rowan)

This student is describing the total engagement a learner has with a truly engrossing activity. Such engagement is seen as a desirable process to occur in any learning environment (Laurel, 1993; Stoney & Wild, 1997), and it has been described most eloquently by Csikszentmihalyi (1992) as optimal experience or *flow*.

Involvement with context

All the students in the interviews said that they didn't really feel as if they were actually teachers reporting to a staff meeting, principally because they knew their classmates well and they were accustomed to giving oral reports to their peers. Interestingly, however, with two of the groups, whenever the students referred to the task they had to perform, they referred to the context of the assessment program—that

is, reporting to the staff meeting—not to their own real life context of reporting back to the class. This was reflected in this comment by Glen:

> Our first step was to get an overview and see what we thought would be good to bring to the staff meeting, things that could be implemented. (Interview with Glen)

While acknowledging that the role was a simulated rather than a real one, one student pointed out the value of relating the experience to the real-life situation:

> I am not really looking at a real class, it is done at a computer. You don't actually get out there and experience it. I don't really feel like a real teacher but I can see how I can relate this to when I do get into a school. (Interview with Louise)

Real life and decontextualised learning

The predominant feature of the context of the assessment program was that students appreciated the real-life relevance of the material they were using. They frequently pointed out the contrast between the authentic context presented in the program and the decontextualised approach. Several problems were evident with the decontextualised learning the students frequently encountered at university. These problems could generally be grouped into three broad metaphors of learning: *learning by transmission, learning by absorption* and *learning by appropriation*.

Learning by transmission

This view of learning sees knowledge as a commodity that can readily be transmitted from the teacher to the student, predominantly in a verbal form. This analogy was used by some students to explain problems with their ability to understand content in their university courses, and to point out the advantages of the more contextualised approach presented in the assessment program:

> Instead of just showing us the theory, it also showed the scenario inside the classroom, so we can do that we go on prac. It gave practical examples which I think the course is lacking a lot of. (Interview with Debra)

Students frequently mentioned 'theories' of learning and teaching, often in an almost disparaging manner, and they drew a firm distinction between theory and practice. The suggestion was that theoretical perspectives are not backed up strongly enough with practical examples in context to enable students to incorporate the course content into their teaching repertoire. For example, Glen describes problems with practical understanding in another area of his course:

> At the moment in education we're doing discipline theories and you get these discipline systems, and you go 'I can't see how that would work in a classroom'. And it would be good to see some of them implemented in the classroom ... Some of the discipline things, I wouldn't feel comfortable implementing them and I can't see how some of them would work by themselves. (Interview with Glen)

While Wilson, R. (1996) points out that 'computer-aided education does not really suit the traditional model of teacher as guru' (p. 11), one of the students related the story that in one of his classes, computer technology was used very much in the transmission mode:

> You could compare it to our other class where our lecturer quickly runs through everything on his little laptop and displays it on the screen and just goes 'You can find this in examples a and b'. And we never look. So he's expecting us to go all the way back and read through all the examples later. We are not going to do it. (Interview with David)

Generally, however, the students viewed the assessment multimedia program and other instances of computer-based learning they had experienced as distinct from the learning by transmission mode. This latter mode was strongly associated with the more prevalent university practice of lectures.

Learning by absorption

Another analogy used by students to describe the learning process in a decontextualised situation was learning by absorption. The implication is that teachers believe that if students are exposed to the content for long enough, they will inevitably 'absorb' the information. One student made this comment in relation to his control over the learning process with the assessment package:

> You basically do it in your own time and at your own speed and you can take in things that you need to rather than have somebody lecture at you and get everything like 'soak, soak, soak'. (Interview with Glen)

Learning by appropriation

This view of learning described by the students sees learning, again, as a commodity that can be captured in a physical form, usually written down or copied from another source, and then regurgitated without understanding to satisfy assessment requirements. Plagiarism is an extreme form of this view of learning (McCalman, 1995). The limitation of a decontextualised lecture situation was described by one student in the following manner:

> We get lecturers who stand up and say something, and we may write it down, then you go back to it later and you don't understand what it means. (Interview with Debra)

And similarly, textbook material can be also be used in a manner that reflects lack of understanding:

> You go into a library and get a book. You've got so many pages and ... you end up sitting there and writing down a heap of stuff. (Interview with Debra)

One student contrasted the methods she and her partner used on the interactive multimedia program with the more common method, in her experience, of supplying 'what the lecturer wants to hear':

> It has really made us think about each of the strategies and why we would use them and why we wouldn't. So that's why I think it's not writing so much what we know the lecturer wants to hear ... like most of our assignments do. (Interview with Zoe)

Real life relevance

In contrast, the real life relevance of the assessment program was one of the more frequently mentioned strengths of the program for the students.

> It was like a real thing. It wasn't like academics discussing the relative theories and things like that, which is what we get lot of at uni. It was actually teachers showing how they'd implemented it and discussing it afterwards. (Interview with Glen)

Some other comments relating to the context, made by students, were that they could relate to the classroom episodes and saw them as being very lifelike. One student described the feeling that she could go beyond the computer representation of the program into the classroom itself. Another student told how he could relate the assessment material to his own situation, and could use some of the strategies to assess two high school students he tutors in mathematics.

The authentic context of the assessment program was even capable of irritating students in a most lifelike manner. Some experienced minor irritation with certain personalities shown on the video clips. For example, one student commented negatively on what it would be like to be taught by a particular teacher, and another pointed out the variations in quality of the teacher interviews: '... others waffled a bit'. Generally these comments were spontaneous, emotional outbursts such as the following:

She's going over questions that they've got right anyway, so what's the use? She's sick. I'd hate her for a teacher. (Observation of Zoe using multimedia program)

Summary of authentic context

Authentic context is the corner-stone of the situated learning model, the fundamental premise upon which the theory rests. The findings in this section suggest that authentic context is valued by students as an element of a multimedia learning environment.

Learning within a realistic classroom situation provides a useful real-life context for the students and compares favourably to their views of the alternative pedagogical methods they frequently encounter at university, such as learning by transmission. Although the students were always aware that the situation was not real experience in classrooms, they perceived the situations to be very life-like and they appreciated the opportunity to engage in tasks and contexts that would prepare them for the challenges of assessing students' mathematics in a real classroom. In spite of the fact that the students were working with a complex resource, they did not feel overwhelmed by its complexity. On the contrary, the fact that the students were able to be engaged with the program meant that they perceived the resource to be very simple, and that their learning was frequently achieved without conscious effort.

However, one area of uncertainty identified in the study in relation to its authentic context concerned the cultural relevance of the program. The interactive multimedia program on assessment represented the students' own culture. Because the program had been purposely made, it depicted local classrooms, local accents and local customs. So local were the video scenes, some of the students in the study recognised former teachers. While the program's authentic context may hold promise for facilitating learning for students in Perth, Western Australia, is that context authentic for students in Queensland, the Philippines, New Zealand, England or the United States? Is it relevant for indigenous cultures within Australia? The issue of cultural context has been raised by Henderson (1994) who points out that values embraced in much interactive multimedia reflect western notions of the nature of knowledge. The portability of the context of interactive multimedia into other cultures (Henderson, 1996; Hart, 1996) is an area that warrants further investigation.

Authentic activities

An authentic activity was designed for students to complete as they used the interactive multimedia program on assessment, to incorporate the characteristics of real life tasks. The activity was ill-defined and unstructured, it required students to find as well as solve the problems, it provided opportunities for students to detect relevant and irrelevant material, and it required sustained thinking over a number of hours to complete.

While the investigation the students completed met the criteria for authenticity proscribed by several theorists and researchers in the area (such as Young & McNeese, 1993, described in detail in Chapter 3), it did not require the students to physically use the assessment strategies in a classroom situation. The investigation was one exemplifying a less typical but more reflective activity of a teacher, rather than a day-to-day, real-life task. It was designed to allow students the opportunity to compare the strategies, and reflect upon the strengths and weaknesses and the best use of each type of assessment.

The students accepted that the task was an authentic one, although there was some scepticism that as neophyte teachers they would be assigned such a responsible assignment, or indeed that their recent experience with learning theory would be valued by school communities. One student explained her reasons for finding the investigation authentic:

> I found it a worthwhile topic to do our assignment on because we are going be using these. We need to use these different types of strategies in our classroom and by going through this program and going through all different strategies ... we learn the strengths and weaknesses, and then give a report ... So it has really made us think about each of the strategies and why we would use them and why we wouldn't. (Interview with Zoe)

Similarly, the students appeared to identify with the problem situation that was exemplified in the letter from the parent:

> Did you read the little bit here? 'To the Principal, I am writing to express my concern at the number of maths tests Lauren is required to take. She gets extremely anxious before each of these tests almost to the point of making herself sick ...' I can understand that. We used to have so many tests in maths for these little things. It is just ridiculous, like every week you'd have a small test. (Observation of Rowan using multimedia program)

The idea of the activity as an organising framework for investigating the assessment multimedia resource was frequently mentioned by students. The following was typical of comments on this issue:

> It's a good way of deciding how to go about looking at the program. It gives you a starting point instead of being confronted with a whole heap of things and told to go for it, it means you have something to keep in mind as you're looking at it. (Interview with Glen)

Another student described how she and her partner used the letter from the parent as the organising context for their investigation of the assessment program:

> So what we did was we went through every single part and just got minimal notes from that, and ... put that into the context of the letter. Because nearly all the assessment is related to the letter. (Interview with Louise)

Despite some scepticism of the value placed on the knowledge and ability of first year teachers, both the situation prompting the parent's letter to the school and the resulting request for a report were seen by the students as authentic and formed the basis of a worthwhile investigation.

The ill-defined nature of the activity

The activity was designed to incorporate all the uncertainty and unpredictability of an authentic task. Students were provided with a copy of a letter of complaint from a parent, together with a memo from the Principal requesting a proposed plan of action to remedy the problem. The task was ill-defined. There was no summarising question or topic for the investigation, simply the presentation of the two documents. Students' first task was to work out exactly what they were required to do. Collins (1988) has pointed out that students often invoke 'suboptimal schemes' for remembering information and to help them cope with the day-to-day demands of school learning. For example, arithmetic students might conclude that any word problems including the word 'left' (*How many did she have left?*) are subtraction problems. Similarly, Schoenfeld (1991) describes a suspension in sense making when students blindly apply rules to problems (for example, the answer 36 was frequently given to this problem: *There are 26 sheep and 10 goats on a ship. How old is the captain?*). One student revealed the 'suboptimal scheme' she normally used for 'finding the question':

> We had to read it four or five times to actually get out what it was asking us to do... because the actual question was in the middle, it wasn't at the bottom and it wasn't at the top, we sort of had to look through and go 'Oh there it is'. (Interview with Debra)

This comment reveals that the student's standard procedure of looking at the beginning or end of an activity for the 'actual question' did not work in this case. Several

students commented on the complexity of the question and its lack of direction on exactly what had to be done:

> I read through it [the investigation]. I knew what it said, but I didn't know how I was going to go about it. (Interview with David)

Another student, when asked his opinion of the activity, pointed out that it had no defined scope or boundaries:

> It was a bit broad really ... Where could you start? Where could you stop? (Interview with Carlo).

Promoting exploration - students find as well as solve the problems

The students spent considerable time not only identifying the requirements of the task, but also in breaking that global task into sub-tasks. There was active engagement in finding and defining these composite problems as well as solving them. One student described the process of 'finding the question' and then going back over the material to work out a plan for completing the activity:

> Because we had the specific investigation, finding the question out was like planning for the alternative strategies and that, so we figured because of the question we were going to have to look at them all first, and then go back. And because it was unfeasible in the time ... we had to go back and decide which ones we wanted to go into further. (Interview with Debra)

The opportunity to detect relevant and irrelevant material

The program was not designed to deliberately incorporate material which was totally irrelevant to learning about assessment strategies in mathematics. Many interactive multimedia programs, particularly those aimed at younger users, incorporate elements which, when selected, present irrelevant material often in a humorous manner (for example, a ballerina on a poster might start to dance, or a fish might jump out of water when each is clicked). It was considered to be inappropriate to include material of this nature in the assessment program, or to include obviously irrelevant material within the context of mathematics education, such as segments on setting up computers or how to teach fractions. The important point is that much of the material included in the program is naturally irrelevant depending on the activity chosen, and is naturally eliminated in the planning stages and as the task proceeds. For example, most groups decided that they would not use all the material, and set about selecting the most relevant cases according to the requirements of the task and the time constraints:

> We did it quite differently because of the investigation. We went through and made up a list of a description of each of the strategies. And when we had that we went through and selected the ones we thought we might present to the staff meeting ... So when we did it that way we didn't look at every part of every strategy because the time we had to do the investigation wouldn't allow for it. (Comment by Debra in focus group discussion)

Sustained thinking by exploring topics in depth

The assessment program was designed to allow students access to a range and diversity of material which would allow them to explore topics in depth, and to apply sustained thinking on a single topic over a lengthy period of time. Students worked on the assessment program over three weeks of their 13 week course unit. This was a total of 9 hours (less time for breaks). The students also had access to the program outside their scheduled lecture times after the second week and prior to their class presentations in the third week.

Given the curriculum and the unit content, three weeks was considered a suitable amount of course time to be devoted to the subject of assessment strategies. However, when questioned about the appropriateness of the time allowed for the investigation, students generally agreed that the time was insufficient. They appreciated the fact that some time limit had to be imposed from a practical, course planning perspective, and that the activity was not 'crammed into a half an hour type time limit' (Interview with Debra). Nevertheless, most indicated that a longer period for investigation of the resource would have been desirable. For example, one student's response was typical, when asked whether the time allocated was too long or too short:

> If anything it was a little bit short ... We probably could have done it quicker if we absolutely had to but we definitely could have taken a lot more time doing it ... So from a practical point of view it was good, but from a personal point of view I would have preferred a bit longer, so that we had a bit more leisure to explore the strategies in depth. (Interview with Glen)

Similarly, Carlo pointed out that he and his partner had sufficient time to investigate the resource but not enough to interpret their results:

> To go through it and interpret our results properly ... I reckon the time we've been given is just not enough ... you start getting comfortable with it and then that's it! It is all over. (Interview with Carlo)

Several students pointed out that the activity provided the focus for the use of the interactive multimedia program, and in so doing provided time restraints which prevented them from exploring the resource at their leisure:

> It didn't seem like we had the leisure to look through and meander here and there if we wanted to. While [the activity] gave us a focus and direction, it meant that we couldn't just meander along. (Interview with Glen)

An alternative use of interactive multimedia programs is implicit in this comment, that is, that they could be used in a much less purposeful way, as references to be explored at leisure, possibly in much the same way the World Wide Web is frequently accessed by students. All the groups of students expressed the view that they felt the allocated time for exploration if the resource was insufficient. This indicates that the resource was sufficiently complex to withstand a sustained examination.

Tasks integrated across subject areas

One of the characteristics of authentic activity that is mentioned by several theorists and researchers in the area (e.g., Jonassen, 1991b; Bransford, Vye, et al., 1990) is that tasks need to be able to integrate across subject areas. The interactive multimedia program on assessment was designed to meet the faculty requirements of semester units in mathematics education which limited its applicability across subject domains. As such, all the examples and scenarios related to mathematics classrooms (K-12). In spite of this, several of the students mentioned the possible transfer of skills to other subject areas. For example, one student pointed out how useful some of the assessment strategies were in other subject areas:

> It's based on maths, the multimedia one was, but I would probably think that it could be applied to anything. It's more general, like I found myself using some of these techniques in my other classes, like English. I thought they helped if you look at them in a general view, not just for maths. (Follow-up interview with Louise)

In spite of the fact that, because of University departmental constraints, the interactive multimedia program on assessment did not aim to deliberately integrate tasks across subject areas, this was a notable outcome for many of the students. This did not occur within the bounds of the task set for the students, but as a result of transfer of skills and knowledge to other teaching areas. This transfer effect is discussed more fully in Chapter 9.

Summary of authentic activity

Authentic activity was defined as a critical component of a situated learning model. The interactive multimedia on assessment incorporated an authentic activity which required the students to respond to a memo on assessment strategies used in a school. The findings suggest that an authentic activity provides students with a meaningful purpose for exploration of a complex multimedia resource provided it is ill-defined, that students define the pathway and the steps to take, and that it is complex enough to enable a sustained investigation of the resource.

The students generally responded positively to the activity and despite initial protestations that they were not told exactly what they had to do, they quickly rose to the challenge of the task and determined a course of action to follow. Universally, students felt that the time allocated to the topic was insufficient, an indication that a an authentic activity allows a sustained and thorough examination of a single resource without tedium. Generally, the findings suggest that authentic activity provides a vital organising framework for a purposeful examination of a multimedia resource.

Expert performances

The assessment strategies program gave students access to expert performances in three ways. Firstly, the video clips of the scenarios being demonstrated in the classroom were generally performed by experienced teachers who were well acquainted with the use of the strategy. Secondly, students had access to the commentaries provided by 'experts' in the field of mathematics education and assessment strategies in the *Interviews* drawer of the filing cabinet. Thirdly, students were able to read the reflections and advice provided by third year student-teachers who were only one year more experienced than the students using the program.

Experienced teachers

The students were generally very positive about the exemplary teaching provided in the scenario videos and focused strongly on the videos as demonstrations of the assessment technique in a real life context. For example:

> It is always better seeing something in action rather than just say having to make it up in your head. (Interview with Rowan)

The contrast between the expert performance demonstration in context and the decontextualised instruction students frequently receive was also highlighted in some

responses. Students frequently spoke about identifying with, or imagining themselves in, the same situation, and how they might approach a particular strategy differently if they were to do it themselves. One student referred to the fact that his understanding of the strategies and their future use would be triggered by the real life context of his classroom situation and a particular need for a suitable assessment strategy:

> When I think what do I actually remember about it ... I think there's not that much but I think that when I go out and need to implement a strategy I'll remember because it will trigger. (Interview with Glen)

The video scenarios were not shot as they occurred in real-life, but were reconstructed from the real events. Several students commented on the 'acting'; another student exclaimed:

> They all know they are on video. Sitting there like mullets. Jeez I have never seen students react like that, start working straight away. I want a class like that. (Observation of Rowan using multimedia program on assessment)

Interestingly, however, some of the students commented on the incidental peripheral learning that is possible from an apprenticeship-like learning situation and revealed the 'window onto practice' (Brown & Duguid, 1993), or the social or cultural insights into classroom life, that the video scenes allowed. For example, Louise commented that watching the teachers in action taught her some things she should *not* attempt, and also ways of interacting with students:

> I think you always learn something from looking at teachers at work. Sometimes it is even what you shouldn't do, but I think from most of these, it was pretty good. I thought they were teaching you even relationships with their kids. You could tell that they had a good rapport with the students. (Interview with Louise)

Third year student-teachers

The third drawer of the filing cabinet allowed students to access the reflections and advice of third year teacher education students studying mathematics method. These comments provided anecdotes and suggestions on the use of strategies, based on the third year students' professional teaching practice in schools, and allowed students using the package to compare their own understanding with someone whose experience was very close to their own.

Only one student responded positively to the third year students' comments. The remainder were either neutral or dismissive, but all used the preservice teachers' comments in the reflective way envisaged by Collins (1989), comparing their own

performance to others in various stages of development. For example, the positive student mentioned the fact that she identified with the author of the comments, and compared her own experience to what she was reading:

> The third year student ones were good because you can relate them to your own pracs ... I was thinking 'I did that' and then you'd think 'Yeah, that's how I felt about it too'. You can really relate to them, because they're so close to the stage we're at in our course ... and we know that they've been through all that we're going through now, and finally going to get there one day. (Interview with Debra)

The neutral and more disparaging comments concentrated on the fact that the students didn't really learn anything new from the preservice teachers:

> Very few of them were useful ... you know, comments that we would make anyway. So it's not as if it opened or broadened our mind or anything. (Interview with Zoe)

Another student acknowledged that it enabled him to reflectively compare his own knowledge to that of another preservice teacher:

> It was pretty obvious anyway what they were saying half the time. You just realise that they were reassuring a point that we knew. (Interview with Carlo)

Mathematics education experts

The fourth drawer of the filing cabinet provided access to the thoughts of acknowledged experts in the field of mathematics education and assessment. When pressed for time these were less frequently accessed than the other items. It is interesting to surmise, in the light of students' earlier comments about decontextualised learning at university, that expert comment is something to which students have grown accustomed. Their university life revolves around expert comment, and this was reflected in one student's comment:

> To be honest I didn't really pay that much attention to the experts ... I suppose you can just go to the library and get things out of the books. It's sort of what you kind of expect. Whereas the other stuff was different more fun ... with the expert you get sick of reading books, and that's when the expert has something to say you totally ignore it. (Interview with Rowan)

One student, when describing the pattern of use of the various elements of the assessment program, indicated that the expert comment was frequently not used because of the nature of the task she had been set:

If we had time we went into the expert part. But quite often we didn't have time because we were running short. So we went through it that way, purely because of the question we had. If it was a different question we probably would have tackled it a different way. (Interview with Debra)

The nature of the investigation is clearly relevant to the items that students feel are important to access. This was also evident in the analysis of the data in relation to students' search strategies of interactive multimedia (Chapter 6). One student admitted that the expert opinion was valuable possibly at later, more reflective stages of the activity, after the video clips had been watched, and another admitted that they were a worthwhile resource:

They were helpful. Like it is from an expert, so obviously they know what they are talking about, so that's why we valued what they said more than the student teachers. (Interview with Zoe).

Summary of expert performance

Expert performances is an element of the situated learning model where students have access to experts performing the skill in the context of a real-life situation. The students using the interactive multimedia program were exposed to the expert performances of experienced teachers, and to the thought of both preservice teachers and mathematics education experts.

The findings suggest that students not only learn skills overtly from videotaped demonstrations, but they also learn peripheral knowledge about the culture and conduct of the mathematics classroom. The preservice teachers' reflections served as a useful measure against which the students could gauge their own understanding of the issues. Expert comment, however, was found to be not as accessible or attractive to students, who in their university careers are exposed to a surfeit of expert comment. It may, nevertheless, be of greater value in the more reflective stages of an investigation.

Multiple perspectives

In their growing understanding of pedagogy, the students recognised the value of providing alternative methods and multiple perspectives in order to help children learn. This was epitomised by Rowan in the following comment:

In this prac I had last semester, she [the teacher] would try and teach something that one or two of the guys would understand and the rest wouldn't. And when she

would revise it she would notice that, and she would go through it in a different way, and it worked perfectly. (Interview with Rowan)

As an important element in the situated learning model, multiple perspectives were provided within the interactive multimedia learning environment on assessment in three distinctly different ways: one related to the way the assessment strategies were presented in the program and the fact that each strategy was shown from each player's point of view; the second related to the fact that students were required to work in groups and so each participant brought a unique perspective to the discussion; and thirdly, in order to complete the task that they were given, students frequently accessed different perspectives by viewing the material several times. Each of these types of multiple perspective is discussed in detail below.

Multiple perspectives of strategies

The assessment program presented a variety of perspectives on each assessment strategy, from the teacher's, student's, preservice teacher's and expert's point of view. Students were very positive about the variety of sources of information presented on the same strategy. One student, however, expressed disappointment at the brevity of some of the interviews, particularly the children's comments. While it is true that some of the children's comments were not particularly articulate or descriptive, in some ways, this criticism is an endorsement of the authenticity of the responses. The children were generally not articulate enough to give critical reflection on the use of the strategy in the same depth that the teacher could, and their comments were generally affective in nature. Another student failed to see any value in having alternative perspectives and saw each media element as simply repetitive:

> Through the cabinet, it had the description and said one thing, and then the student teacher said exactly the same thing, and then the interview said again exactly the same thing, and I mean it was repetitive, very repetitive. (Interview with David)

Not all the students shared this view. Most saw a value in the different perspectives that they were unable to find in other more traditional methods of learning, and they appreciated the sometimes subtle differences in perspectives. One student, comparing the program to a traditional lecture, indicated that the multiple perspectives provided many 'avenues to understanding':

> In a lecture you can't click onto the video and get the video to play. When you've got a huge lecture situation, the lecturers can't keep stopping and going ... Whereas with this it gives you so many avenues to understand it from. You may not understand the theory side but you can understand the scenario side and then find out what the

teacher thought. There's just so many different ways of looking at that one strategy. (Interview with Debra)

Multiple perspectives of participants

In order to complete the task, students were required to work collaboratively, an arrangement which inherently provided for the sharing of each participant's unique perspective. Several students pointed out that the arrangement of students into collaborative groups was in itself a way of exploring alternative perspectives, because inevitably different people approach tasks differently. For example, the following comment was typical:

> You can get two different perspectives and different ideas and sometimes you just get something completely wrong and the other person can bring you back into line. (Interview with Rowan)

The unique perspective of students, and other benefits of collaboration, are discussed in greater detail later in the chapter in the section on *Collaboration*.

Multiple perspectives of task

The task students were set as an investigation required them to present a report which included implications for three different groups. Prompted by a complaint from a parent, the 'new teachers' at the school were asked to prepare a suggested plan for assessment in mathematics 'including benefits and problems for *parents, students*, and *teachers*'.

It was envisaged that this requirement would prompt the students to view the material separately from each perspective, in effect 'criss-crossing' the resource in a manner enabling them to access the same element from many different points of view. Not all groups completed the different perspectives required in this task beyond recommending a suggested assessment plan for the school. Almost all the groups admitted to trying to assess each perspective simultaneously, because of a lack of time. For example, one student summed up the approach taken by most groups:

> We did it all in one go. It was a matter of finding some advantages of this, and I suppose you break it down as you are thinking about it, but just go 'What advantages have we got for the teacher?' and 'What advantages have we got for the students?' but just do it all at once. (Interview with Rowan)

One student admitted to concentrating solely on the teacher's perspective. He attempted to justify it more convincingly by pointing out that the teacher's perspective would be most relevant to the teachers in the staff meeting, although he qualified his justification as he reflected on his answer:

> I guess we mainly focused on it from the teacher's point of view ... which thinking back doesn't make a whole lot of sense since the parents are the ones who complained about the lack of range of strategies, but it just seemed like a logical way to go at the time. (Interview with Glen)

One student commented on the importance of considering the perspectives of all the interested parties, and in so doing acknowledged the holistic nature of the problem:

> If you are in a classroom situation all those people are, in effect, learning. Like the parents, their motivation and encouragement will make the child react differently. So if the parent makes a big deal about tests, then the child will have a problem with them and get anxiety. Looking at all of them is a good idea. (Interview with Louise)

In spite of this failure to consider the three perspectives required in the task, there was much evidence to suggest that students viewed the material several times, in different ways, and used 'alternative routes of traversal ... criss-crossing a topic in many directions' (Spiro, et al., 1987, p. 188). Regardless of which pattern of use was adopted, students rarely used a linear or regularly systematic approach in searching the media elements. Several students spoke of looking at items more than once if necessary, going back over items, and investigating individual elements in greater depth. The following comment indicates the importance the student places on revisiting the material in order to be able to reflect upon it and make appropriate links:

> We were not really given enough time to go through it and interpret our results properly, because ... we have only really gone through say once or twice at the most ... Really, you like to go through it and be able to make links between this and that and think about it. (Interview with Carlo)

One student suggested the potential value of completing more than one investigation (there are five in the *Investigations* section of the notebook) in order to provide the opportunity to look at the *same* strategies from a different angle, or in the student's words 'a different way of looking at the strategies' (Interview with Debra). This is consistent with the techniques used by the Cognition and Technology Group at Vanderbilt (1990b), who provide parallel investigations using different contexts and details, but which essentially develop the same skills. Such an approach is arguably a more authentic way to provide students with opportunities to gain multiple

perspectives on any given strategy, and would be worthy of further research. An interesting question would be whether the resource base was robust enough to withstand a third or fourth investigation without inducing a feeling of over-exposure to the individual media elements, as suggested by Young (1993). If so, the possibility exists for the resource to be used in a more cross-disciplinary manner. The cross-curriculum value of the assessment package was highlighted by one student who pointed out that many of the strategies were appropriate for language and other subjects but that she would not have related them to mathematics:

> Maths has a lot of negative connotations, and I wouldn't have thought of using half of those strategies. You relate them more with language and the other subjects and it was just interesting to see how you would use them with maths.(Interview with Debra)

Summary of multiple perspectives

The necessity to provide students with opportunities to gain multiple perspectives was considered a critical characteristic of a situated learning model. The findings demonstrate that multiple perspectives can be provided for in several ways. One way is for students to be given different opinions and thoughts from different parties within the program itself; they can also be exposed to others' unique perspectives by working in collaborative groups; and they can be required to approach the same material from different perspectives through the task they complete as they use the multimedia resource. While not all students in the study appreciated the subtlety of perspective such variety of opinion affords, most were aware of the impact such perspectives could have on their learning and they valued the fact that they had a choice. The unique perspective offered by the student's partner was also appreciated in providing a richer combined response to the learning environment. The non-linear navigation of the interactive multimedia program enabled the students to 'criss-cross' the resource with ease, and facilitated their visiting and re-visiting individual elements according to the needs of the task.

The opportunity to gain only a single perspective on assessment strategies (that is the author of the interactive multimedia program) would have resulted in a static, linear multimedia program, perhaps better presented as a book. The ability to provide a variety of perspectives both in the program itself and in its use, is an essential element of a situated learning environment, and is a capability that is particularly suited to the medium of multimedia.

Collaboration

While using the interactive multimedia program on assessment, students worked in small collaborative groups of 2-3 students grouped around each computer. The students were accustomed to working collaboratively from their university courses, but none had worked in groups during their secondary education (one student attributed this to the fact that group work is noisy). Prior to the work on the assessment program, the students chose their own partners. All groups to be observed were dyads. Three of the four sets of partners were accustomed to working together; one pair had never worked together.

One student, from the pair who were not accustomed to working together, was the least positive in her opinion of collaborative groups. This group comprised two young women students who were very tentative with each other in their approach to the use of the resource. One summed up the problem:

> I would rather do it by myself. Plus also, every time you did something you sort of said 'Well which part do you want?' and I'd say one thing and 'What would you do?' and she goes 'Well oh I don't know'. So it was a bit hard trying to decide what information you wanted ... I felt that having a partner there you had to consult them all the time ... but then again doing it with another person you could talk about it. (Interview with Louise)

It is worth noting that Louise qualified her response at the end by commenting on an advantage of working with another person. Her partner, Evie did not share her views. Both Evie and the remaining groups were all very positive about the collaborative arrangements, and wholeheartedly endorsed the fact that they could choose their own partners:

> I think maybe if it was with somebody else that I didn't know too well, you might be a little bit more cut off in the discussion ... So I think it was important that you picked your own groups. (Interview with Zoe)

Rowan also pointed out the difficulties of working in groups assigned by the teacher:

> If it's just a brand new class together getting yourself into groups is a bit more daunting ... I disagree with teachers who would just say 'You're with him, You're with her'. I don't like that. (Interview with Rowan)

When questioned about their opinions of the group work done on the assessment program, the students perceived many clear advantages in working collaboratively. These advantages are discussed below.

Joint problem-solving

Several students pointed out that the completion of the task benefited from collaboration with another person, essentially that view that 'two heads are better than one'.

> You get two perspectives ... if you're working on your own you think 'What's that word?' and you just can't think, but if you've got somebody else, it's like having two vocabularies, and two memories. (Interview with Glen)

This view encapsulates the view that each person brings their own set of experiences and learning to the situation and that each is capable of contributing to the completion of the task in his or her own unique way. In so doing, all the groups engaged in collaboration, not simply cooperation, as distinguished by Katz and Lesgold (1993, described in Chapter 3). The difference between cooperation and collaboration was captured in this comment by Rowan:

> You can always fall into the mistake of, for example, we're both doing something at home, we go miles down the pathway and then come together and we've gone different paths. And to put this together is very difficult, yes? That was the advantage of two weeks of only being able to do it in that class ... cause then you won't stray down a different pathway. (Interview with Rowan)

No group employed a simple division of labour, and all worked synchronously to create a product which could not have been completed independently by either individual.

The partner as teacher

A frequently mentioned advantage of working collaboratively was that the partner often helps by telling or explaining something that the student didn't know or understand:

> In pairs ... you are learning new things all the time, and you are learning ... things that you probably didn't know about, and in turn you're feeding them information which they probably didn't know ... you're richer in information when you have got more than one person working on a report. (Interview with Evie)

The view was also expressed that, at times, collaboration is essential to continuation of the task. In the absence of a partner, this support would be provided either by the teacher, or as one student pointed out, by 'annoying' the person on the next computer:

> The fact that if you're confused about something you can ask somebody and they're right there next to you. You don't have to put your hand up and wait till the teacher gets to you. And you're not ... trying to annoy the person that's on the next computer, you're actually on the same computer and you're doing it together, which just makes it so much easier when you're confused about something or you're lost or you've forgotten the question. You've got someone to ask. (Interview with Debra)

This view sees collaboration as essential to learning, that it is sometimes obtained by stealth, and that it is given necessary legitimacy by the arrangement of students into small groups. Interestingly, one objection to collaborative work is that when it is performed in computer laboratories it disturbs other students who are working individually. But the student's comment suggests that such disturbances are inevitable, regardless of group or individual work, and that people want to collaborate, and they will do it even at the expense of disturbing others not connected with the exercise.

Learning by articulation

One recurring advantage to working in collaborative groups, as perceived by the students in the study, was the benefits of articulating their knowledge to their partners. This was frequently explained in terms of the student explaining something to his or her partner and, in so doing, developing a deeper understanding of the issue. The following comment was typical:

> When we were doing our notes, it would be like 'What does that mean?' and you would have to explain exactly what you meant. You'd have to explain and explaining always clarifies no matter what you're doing. (Interview with Glen)

Articulation in collaborative groups was seen as a major advantage of working with others. The issue is explored in greater depth in the following discussion on *Articulation* as one of the elements of the situated learning model.

Support and scaffolding

Some students introduced the notion of scaffolding to their discussion of the benefits of collaboration. Scaffolding occurs when one student supports the other to extend his or her understanding of an issue. One student described his perception of the benefits of scaffolding:

> Like when you go 'Oh cool, this is what it means' and the other person, who might not have even considered it goes 'Oh yes' and then takes it a step further. (Interview with Glen)

Scaffolding in collaboration with a partner is discussed in greater depth below under the heading *Coaching and scaffolding*.

Negotiation

As Bruner noted: 'All meaning is negotiated; all knowledge is transactional' (quoted in Latchem, 1993). The students in the study were well aware that a process of negotiation was necessary in collaborative learning groups. One student described negotiation as a relatively simple process:

> I asked him what structure he thought we should do it in and if I agreed I just did it, and if I didn't agree I told him so. I think we worked together. (Interview with Debra)

The same student also pointed out some of the more difficult aspects of negotiation on a common task:

> I suppose sometimes if you don't agree on how something's to be done you just grin and bear it. There's two of you and there's no point arguing because you're just not going to get anything done. Because there's a lot of times I suppose where you've got your own idea, 'I want to do it this way and I don't want to do it any other way'. We didn't really do it that way, but on occasions it could happen, especially formulating a plan like that. Somebody may have a different way of going about it and they might get into an argument and have a clash of personalities, and then your learning experience wouldn't be all that crash hot if that happened. (Interview with Debra)

The issues and potential problems raised in this student's response—coercion, compliance, conflict and discomfort—are all possible processes and outcomes of a collaborative learning arrangement. Apart from one group which adopted a fairly heated, albeit affected, confrontational style—in Zoe's words 'We just start yelling at each other'—none of the groups in the study appeared to experience any of these problems in their working relationships. This is possibly due to the fact that they were in collegiate collaborative groups of their own choosing.

Disadvantages of working collaboratively

Few students had firm ideas on the disadvantages of working in collaborative groups. When asked the question directly, surprisingly, many deferred to reaffirming the advantages of working with a partner. One perceived disadvantage was that working in groups is much slower than working alone:

> It always takes longer. If I'd done it myself I probably would've done it quicker, maybe not as well, but faster. I work faster alone. (Interview with Glen)

The emphasis in this response is on the final *product* rather than *process* of learning, a point acknowledged by the student in his admission that the task would not have been done as well alone. Several of the students raised the problem of a group member who does not contribute substantially to the final product. For example, Zoe related her experience in working in another group which had this problem:

> With the group that I was in, actually, I must admit it was fine, except one girl didn't pull her weight. So I got angry ... our presentation on it all went fine, except that girl didn't pull her weight. (Interview with Zoe)

Fuller (1996) suggests that such a problem can be ameliorated by requiring a group consensus on the proportion of marks to go to each member of the group, allowing each to acknowledge a greater or lesser contribution. One student also suggested that the problem is less likely to occur in smaller groups or pairs, because it is then more difficult to avoid an equitable load.

Summary of collaboration

Collaboration is an element of the situated learning model defined in Chapter 3. In the present study, students were required to complete a task using the interactive multimedia program on assessment in small collaborative groups. The findings suggest that collaboration is a vital component of a situated learning environment, and that collaboration assists in providing for several other elements of the model such as *Coaching and scaffolding*, and *Articulation*.

The students were generally very positive about working collaboratively and saw many benefits, such as joint-problem solving, the necessity to negotiate their learning, and a product which is of better quality than one done individually. The only benefit of working individually was that work could usually be done more quickly, although this was qualified by one student, who admitted that it was usually not done as well. Collaboration appears to be a pivotal element in the situated learning model, and one upon which many of the other elements depend for their execution.

Reflection

In order to provide a learning environment which would promote reflection, the assessment program was designed primarily with an authentic context and an

authentic activity to enable students to engage with the program and to reflect upon it in a meaningful manner. It was also designed to enable multiple entry points, non-linear navigation, and access to an electronic notebook to enable students to note their reflections and ideas immediately. The program provided expert commentary, together with other comment by preservice teachers, to enable students to reflect upon and compare their performance with others in varying stages of expertise. Comparison with experts as part of the reflective process has been discussed above in the section on *Expert performances*.

The observation of the students confirmed Kemmis' (1985) belief that reflection is a social process. This was established by one student in the following comment:

> And you're not just thinking to yourself. You're thinking aloud to somebody else, and if they have anything to say to you they will. (Interview with Debra)

All the students provided evidence of the three stages of the process of reflection as defined by Boud, Keogh and Walker (1985 described in detail in Chapter 3), in spite of the fact that overtly, some of them had a very narrow idea of the definition of reflection. For example, when questioned on how the program enabled him to reflect, Carlo replied that he hadn't had time to consciously reflect. And yet some of his comments were amongst the most insightful on the role of reflection in learning. Notice in the following comment how he gave an almost stereotypical view of reflection, that it is an isolated, individual activity:

> I didn't really reflect much ... if we had a print out of our notebook then we could go home and have a look and reflect, but ... I didn't actually put any extra time into it to have a look. (Interview with Carlo)

However, a little later, Carlo commented on the on-going process of reflection which is very close to the view of the reflective process held by Boud, et al. (1985):

> It's an on going thing ... It is not like I am learning something, a new concept, and I have to rote learn it. It is just there. It is just making links and building a bit more on to what I already know. So basically the reflection just goes on. (Interview with Carlo)

Boud, et al.'s three stages of reflection were detected in the all the groups' discussion and comment as they used the assessment program. Each of the three stages is discussed in more detail below.

Returning to the experience

There was much evidence in the videotaped sessions and transcripts of students reflecting in the first stage of Boud. et al.'s (1985) definition of the process of reflection. The students frequently returned to the experience, recollecting the important considerations and relating them to their partners. Awareness of this process, regardless of whether the students recognised it as reflection, was also evident in their comments in the interviews. In the following comment, Zoe explained the process that was occurring within the examination of a single strategy:

> You could think back to the scenario and then everything would pretty much come together ... Then you could remember what the sample was and a bit of the description, and what we wrote about it, and so that was really good—another reason why it is better than a textbook. (Interview with Zoe)

A more general perspective on the use of the whole resource was provided by Rowan, who pointed out that a single perusal of the material is inadequate:

> We ended up looking at a lot of things twice. Which is quite reassuring when you look it at the second time around and then you get ... a better understanding ... If I have looked at it a couple of times, it is a lot easier. Everything I associate with it is a lot easier. (Interview with Rowan)

The assistance of the student's partner—an 'appropriate reflector' (Knights, 1985)—in aiding reflection was also a strong feature of this stage of the reflective process. For example, Carlo explained that the collaborative process facilitated his reflection, with each person contributing their experiences and anecdotes, in effect to 'enlighten each other'. Another student also pointed out that this stage of the process was not confined to the computer laboratories in the scheduled classes, but that it spilled over into their own time:

> We'd talk about it, and I'd bring it up and say 'I was thinking about doing this for our assignment' or whatever and we would just start talking about it out of class, which is quite unusual for us. (Interview with Zoe)

Such a suggestion is also reminiscent of Csikszentmihalyi's (1992) notion of *flow* where, in this case, the sense of interest and engagement with a project is not bounded by the restraints of formal exercises and classes.

Attending to feelings

The second stage of the reflective process was also evident in the students' use of the assessment program. In this stage, students accommodate positive and negative feelings about the learning experience, and they frequently use anecdotes and stories in their discussion in this process. For example, in the following comment, Rowan at one level described the process of working with the interactive multimedia resource, but in so doing he also described the way he and his partner attended to positive and negative feelings about the learning they were experiencing:

> We roughly defined the task first ... and then we set out rewording things ... so that we understood our own terms. And then we went through and made sure that we agreed with everything we had down because there was some that we just didn't think really suited. We would leave one or two out but we would include most of them. And we just made some sort of sense out them that way, and gave an explanation, advantages, disadvantages and a few other bits and pieces down the bottom to do with problem solving, just some ideas that we came up with. Like for example one of mine was when I was doing a primary school practice I was tutoring one of the young grade sixes there and he had a major problem with tests ... He would score 10% on the test so I didn't call it a test. I got him to really relax and got him to do this 'worksheet' for me and he got 90%. (Interview with Rowan)

Re-evaluating the experience

The re-evaluation of the experience and the integration of new knowledge, the final stage of the reflective process was also well represented in the students' talk as they used the multimedia on assessment. For example, Evie pointed out that reflection on her learning about assessment has given her a whole new perspective on the subject:

> We have been talking about assessment in the past but I think I've looked at it in a different light now. I have reflected on it and I have looked at it a lot differently than I have in the past. (Interview with Evie)

Many of the students deliberately attributed the electronic notebook as an aid to reflection in all the stages of the reflective process, but most usefully in the third where the new knowledge is integrated into that which is already known:

> Having the notebook there meant that you could go 'What did this bit that I've just looked at mean?' and then you could put a little note in the notebook and then you could go back and look at the next bit. ... If it hadn't been there we would have just read it all through and then said 'What did it all mean?' So the notebook really helps you reflect. (Interview with Glen)

Students also valued the non-linear aspects of the navigation of the program as an aid to their reflection, again in all stages, but most particularly in the third. For example, when asked how the program helped her to reflect on her learning as she completed the activity, Louise implied that the ease of navigation was an important feature:

> You could go back ... If you went down a bit and found out there was a bit of information that related to something else, we could go back and include that ... So you could go through and re-edit your stuff all the time, and look back on everything and go back into the classroom scenarios and see it again. (Interview with Louise)

Brown and Duguid (1993) have pointed out that abstractions become problematic when they are dislocated from the practice from which they originate. They argue that it is important to ensure that abstractions are a function of their social location not imposed from outside. In other words, the abstract is best discovered from concrete examples, rather than the other way around. This point was acknowledged by one student who highlighted the importance of reflection in this process. Carlo, in discussing the role his partner had in helping him to reflect, pointed out that the process of relating new knowledge, and integrating it into his existing conceptual framework, enabled him to move from a concrete to an abstract way of thinking:

> He was always giving examples, like you could probably hear from the tape, he was going 'Oh its got this and that' and so it is definitely from experience. That is what it is all about. You've got to relate to other things, so you go from concrete to the abstract. (Interview with Carlo)

Summary of reflection

The opportunity for students to reflect on their learning is a component of the situated learning model described in Chapter 3. The principal design features to embody this characteristic were an authentic context and an authentic task to enable students to reflect in an engaging and captivating learning environment, rather than as a response to external cues or reminders.

The findings suggest that the learning environment did allow students to freely reflect on their learning by providing them with a multimedia program and collaborative working arrangement which enabled them to return to experiences, attend to feelings and to re-evaluate the experience. The students were able to share their reflections with each other and use the notebook facility to conveniently record them. Importantly, the learning environment enabled new knowledge to be integrated into students' existing conceptual framework and to move from a concrete to an abstract way of thinking.

Articulation

Students articulated their understanding of assessment strategies in two ways: the formal report to the staff meeting, and in their discussion with their partner as they used the program.

Many interactive multimedia programs do not allow either form of articulation to occur. Students are assigned individually to computers to work alone, and in so doing, the knowledge remains tacit. Lave and Wenger (1991) point out that being able to speak the vocabulary and tell the stories of a culture of practice is fundamental to learning. The students who were observed using the assessment multimedia program were clearly aware of the difference between tacit knowledge and verbalised knowledge. One student pointed out the difference between 'knowing' and verbalising in a manner which suggests that the knowledge is incomplete unless it is articulated:

> Like self-assessment, I didn't understand a lot of that and I don't think I could give a lecture on it or anything but I know basically in my mind what it's basically about, so if I was asked to go and research it I could, because I know where to start because I have that background. (Interview with Debra)

This student is saying that knowing 'in my mind' is little more than a good starting point for further research. Another student drew a comparison of tacit knowledge with affective learning, pointing out that such knowledge can be little more than feelings about the subject:

> If you're explaining something to yourself you think 'Yeah, I know what that means' but there's lots more feeling things in there, but when you have to put it into words, it clarifies it all. (Interview with Glen)

Verbalisation and understanding

The students were clearly aware of the importance of articulation to learning. However, they almost invariably viewed articulation as an act of clarifying an issue rather than an integral part of the learning process itself. For example, the following is typical of a number of comments made by students on the 'clarifying' role of articulation:

> Glen would say 'What do you reckon', and we'd say to each other what we'd think, and the other one would say 'No, I don't think that' and you'd have to be able to explain yourself, and to be able to explain you'd have to have learnt something. So it's just a way of clarifying ideas. (Interview with Debra)

While this student is clearly aware of the value of verbalisation, such a view underestimates its importance in the learning process. As described in Chapter 3, counsellors and psychologists effectively use verbalisation to affect change in problematic behaviours. The implication is that the very process of articulating enables awareness, development, and refinement of learning. One student acknowledged this interdependence in the following comment:

> If you have to put something into words, you have to think. (Interview with Glen)

Another student, when asked about the advantages of articulating to his partner related verbalisation very closely to his own view of the learning process:

> It gives you like a better chance to make links, and that's what we are always trying to do to—make links from the old ... it's all about making more links. (Interview with Carlo)

Articulation in formal presentations

Students using the assessment package were very much aware of the value of formally articulating their learning in the presentation of reports to their classmates, or as Pea (1991) describes it 'creating rich conversational artefacts for discussion and presentation' (p. 65). Students were surprisingly positive and comfortable with the prospect of presenting a report to a larger group (given that fear of public speaking is often ranked more highly than fear of death in popular surveys) and in this sense, they may not have been typical. However, one student pointed out that reports to class were more and more becoming a standard feature of their university classes:

> It's getting to be more of a normal occurrence. We've just done a class presentation in Education, and you end up doing a few reports here and there. I've never been particularly worried by public speaking so the report didn't really bother me. (Interview with Glen)

Students spoke at length about the planning that went into their presentations, and much of the video transcript was devoted not only to discussion about what would go into their verbal report, but also the manner of its delivery. Students were particularly concerned about ensuring that their reports were presented in a clear and concise manner:

> You have to understand what you are talking about because if you get up there and you don't understand what you are talking you look like an idiot, and that is the last thing you want to do. (Interview with Louise)

The reactions of the audience could also be useful, according to several students, in gauging the effectiveness of the presentation. David mentioned that questions from the audience serve to 'challenge our understanding' and give students the opportunity to publicly defend their understanding. Another student, when asked whether she thought that giving a report to the class had helped her learning, commented:

> Yes, because you have to be able to explain it in simple terms so that people can understand what you're talking about. If you just script in straight from the computer people would say 'Oh not really', and just looking around you can see whether people are understanding what you're saying, and if they don't you have to re-explain it. (Interview with Debra)

The point the student is making here is that the capacity of the audience to respond and question the findings of the report means that the presenter cannot merely copy large amounts of text and present that in the report. The possibility always exists that further explanation will be necessary, and therefore a deep understanding of the material is essential. This care to know the presentation material well was reflected in another comment:

> Because we had to give the report meant that we looked at the bits we were doing more carefully, in that we had to know what we were going to say. (Interview with Glen)

Summary of articulation

The opportunity for students to articulate their understanding of assessment, as defined in the situated learning model, was provided by a social learning situation where students discussed the task in collaborative groups and then presented a formal report to the class.

The findings suggest that the opportunity to verbalise their thoughts in the small collaborative groups enabled students to be aware of their learning and to make appropriate links to incorporate it into their cognitive framework. The formal presentation to the class was a valuable opportunity to articulate and defend their understanding of assessment strategies.

Coaching and scaffolding

The students were required to work in small collaborative groups as they completed the investigation using the interactive multimedia program on assessment. The teacher

of the class was available to them for the scheduled class time to provide coaching and scaffolding, in addition to that provided by the student partner, as required.

Coaching and scaffolding role of the teacher

The teacher of the class being observed was thoroughly familiar with the program and its possibilities. He had been briefed on the broad requirements of the coaching and scaffolding role prior to the class (see Appendix 5). At the beginning of the lesson, the teacher introduced the issue of assessment and provided brief instructions to students on the program elements and how to access them. He modelled a problem by thinking aloud as he demonstrated how he would go about investigating it. Once the students were set to work in small groups, he was available to students at all scheduled class times when they were using the program, and responded to student's requests for assistance. He frequently initiated assistance by moving around the class asking students if they needed any help, but did not impose gratuitously on them.

The teacher was consulted on a number of occasions to assist students to clarify the requirements of the task they had been set as their investigation. Students also consulted with their teacher when they had a problem or question related to the software or equipment, such as how to print from their notebooks, how to correct audio problems, or how to move in and out of the program and save their work. Table 7.1 provides a summary of the specific support provided by the teacher to each of the groups of students as captured by the video recordings. These interactions are categorised under the headings *Announcements to the class*, *Social, Procedural, Lower order* or *Higher order*. The last four categories mirror the framework for analysis of student talk used in Chapter 8 to determine whether students used higher-order thinking as they used the assessment program.

Table 7.1:   Frequency of support and scaffolding provided by teacher to groups

	Group 1: Glen & Debra	Group 2: Louise & Evie	Group 3: Carlo & Rowan	Group 4: Zoe & David
Announcements to whole class				
Clarification of requirements of task	✔			
Warning of 15 minutes time remaining	✔			
Instructions on saving the notebook to disk	✔	✔	✔	✔
Procedure for printing notes		✔	✔	✔
Location of computer laboratories		✔	✔	✔
Social				
Conversations about teachers featured in the program scenarios	✔		✔✔	
Joining in social conversation				✔
Procedural				
Clarification of requirements of task	✔			
Demonstrating video clips playing smoothly	✔			
Advice on waiting for video to play			✔	
Assistance with volume adjustment		✔	✔	✔
Providing directions on saving notebook		✔		✔✔✔
Advice on how to activate the cursor			✔	
Explaining the capacity of the notebook			✔	✔
How to copy when text did not highlight		✔		
Advice on using the cursor to move around in the notebook				✔
Cleaning mouse		✔		
Dealing with disk error message		✔		
Explaining which computers had CD-ROM drives				✔
Lower order				
Videos were different for each strategy			✔	
Higher order				
Directing students to a diagram in the samples drawer in response to a problem	✔			
Explaining a contradiction between the scenario and the expert's comment				✔

As can be seen from Table 7.1, the majority of instances of support provided by the teacher were procedural in nature, although all categories were represented. The assistance provided by the teacher was procedural on content (e.g., Is it meant to be a written report?), software (e.g., There's no sound on this video) and equipment (e.g. Our mouse isn't working very well). The role of the teacher was seen by the students as one which essentially clarified issues for them and was important because it saved time. It enabled the students in the study to proceed with the knowledge that their

efforts were 'on the right track' and that the support given to them was precisely at the point they needed it.

The students appreciated the procedural assistance provided by the teacher and all seemed to think that such support is vital in a computer-based learning environment. The feeling was that if the computer failed, there was virtually nothing students could do, a situation which was unlikely to occur in more traditional print-based learning. For example, this student highlighted the importance of having the lecturer there in case of a problem:

> I have had classes before where we have been working on a computer and the lecturer just didn't bother turning up and ... if you have a problem and you can't work it out yourself, there is no-one there to help you. You'd sit there doing nothing and it is waste of your time. (Interview with Louise)

For procedural problems, the teacher generally fixed the problem himself as quickly as possible. However, for higher-order problems, the teacher was asked to provide assistance to students, not by supplying the solution, but by giving just enough guidance—the 'scaffolding'—to take them to the next stage, or as Savery and Duffy (1996) point out, interactions that occur mainly at the metacognitive level.

In the lessons observed, however, students rarely consulted the teacher on higher-order questions related to the task. In the two occasions they did, the teacher provided adequate scaffolding in the first instance by directing students to a diagram, and in the second by engaging in a discussion on a contradiction found in two of the media elements. Neither instance involved any kind of judgement on the teacher's part. Rowan's comment on the role of the teacher reflects his belief that the teacher's role is principally one of a guide:

> It's just reassuring that way he comes around. He doesn't say anything just has a look and that's a bit more reassuring ... A lot of teachers will just step in and just say 'You're wrong' or 'Don't do it this way. Do it that way' whereas if they step back and look at guiding through it, just something like looking at other people's perspective or having a look at this might help, rather than saying 'That's wrong' ... No one wants to be told that they're wrong. (Interview with Rowan)

In spite of the fact that the teacher was rarely consulted, the students themselves felt that they were adequately supported by the teacher:

> Well there wasn't an awful lot of it [assistance from the lecturer], but there didn't need to be. Basically, the help that we got, which wasn't much, was appropriate. (Interview with Glen)

Maor and Taylor (1995) point out that it is important for the teacher to refrain from exerting too much control in such computer-based learning environments or risk 'disempowering students' (p. 852). Clearly, such a threat was not evident in the nature of support provided by the teacher in the study.

Coaching and scaffolding role of the partner

The arrangement of students into collaborative groups, meant that the student's partner could provide a coaching and scaffolding role. This support was particularly evident in the higher-order thinking related to the investigation the students were doing.

In procedural matters, such as clarifying the requirements of the task, the students were not able to determine precisely what to do. They offered suggestions to each other but could not decide without the assistance of the teacher. However, in dealing with the content of the interactive multimedia program, they assisted each other considerably in both the mathematics that was presented in the segments and also the assessment strategies. The students were aware of the influence interactions with their partner had on the depth of their learning. For example, when asked to describe the advantages of working in pairs, Glen showed considerable understanding of the concept of scaffolding and how it relates to his own learning:

> If you've got somebody else ... you scaffold a bit. Like when you go 'Oh cool, this is what it means' and the other person, who might not have even considered it goes 'Oh yes' and then takes it a step further and you end up doing more indepth thinking about it because otherwise I might just have a bit of a superficial look at it. (Interview with Glen)

Students were very positive about the supportive role their partner played, and clearly linked the arrangement of students into collaborative groups to the value of articulating their own growing understanding of the issues. They also indicated how useful a partner can be when problem-solving. Referring to the use of computer-based programs by individuals, Debra indicated that assistance, when required, is frequently obtained from another student working on a nearby computer. This arrangement is not without problems, and highlights the advantages of a partner working on the same task on the same computer.

The importance of the scaffolding role played by the partners in the collaborative groups was an unexpected finding of the study. It was expected that interactions with the lecturer would have provided greater metacognitive support for the students. However, the findings support very closely Vygotsky's (1978, p. 86) notion of the

'zone of proximal development', where students are supported by 'more capable peers', students who are more likely to be operating within each others zones (Slavin, 1996).

Summary of coaching and scaffolding

Coaching and scaffolding was included in the recommended implementation of the interactive multimedia program on assessment rather than as an intrinsic part of the software itself. It was generally seen by the students as an important aspect of the learning process. From the analysis of the data, it is apparent that coaching and scaffolding is provided not only by the teacher, but also by the student's partner in the collaborative groups. An important concern of students was that it was essential that assistance be available at the time of need, and that failure to attend to these immediate needs would result in time being wasted.

In the present study, the role provided by the teacher was principally related to procedural matters of both content and software. Complementary to this, the scaffolding role provided by the student partner was frequently fundamental to the learning process, and provided considerable higher-order support in completing the task.

Authentic assessment

The assessment program included an activity which required students to propose new assessment strategies for the mathematics department in a school. It was this one activity which they investigated for the entire three week period, and it was this activity upon which they were assessed. Students were required to give both an oral and a written report of their proposal. Several themes emerged from the students' comments on assessment and these can usefully be reported within the framework established in Chapter 3, which suggests seven criteria that determine the authenticity of assessment.

Fidelity of context

Generally, students found that being assessed within the context of a teacher presenting a report to his or her colleagues during a staff meeting was a useful one. They recognised the activity as the kind of task they might be required to perform as teachers, and saw it as good practice for that event. One comment was:

I guess it's practice for future times and it means that you're looking at things from a professional perspectives. It's like pretending and you become a teacher for a while. (Interview with Glen)

Carlo drew a distinction between being assessed in an authentic or traditional manner by referring to the use of the skill in its real life context:

In the real world things get done in reports. You don't write an essay to the boss. You write a report of your findings ... and your conclusions. (Interview with Carlo)

Another student commented on the fact that as she was learning to be a teacher, it was entirely appropriate that she should be given the opportunity to practise the necessary skills:

We are here to learn how to be teachers and a teacher at some stage in their teaching career would have to write a report on assessment in their school so I think it is good that we can do it that way. (Interview with Louise)

This student seems to be implying that her teacher training course has a responsibility to prepare her for her real life role, and that the use of an authentic context is an important factor in achieving that. This idea was extended by another student who suggested that teaching is a complex, multifaceted activity comprising many more demands than the face to face teaching of students. This opportunity to practice associated roles, other than teaching lessons, was valued.

The activity the students completed required them to investigate new assessment strategies that might be used in the school. They were invited to do this because they were new to the school and possibly had fresh ideas from their university training. One student commented cynically that this was an unrealistic situation, and fairly unlikely to occur:

It seems a bit unrealistic, like it doesn't seem we are going to go to a school and they will say to us 'You're new to this school so we want you to write a report'. (Interview with Zoe)

Another, however, expressed that this *was* a realistic request, which also implies his belief that schools put some value on the theoretical basis for teacher training:

Obviously if you're the new teachers, they would want you to do this because you'd just had all the experience and all these new theories ... so yes I suppose it's a pretty realistic sort of task. (Interview with Carlo)

Generally, the students appreciated the opportunity to be assessed in a real-life, if simulated, context. One student, however, suggested that the fidelity was not true enough. In this comment, Zoe proposed that the context should be even more authentic, by actually presenting real proposals at a staff meeting in a real school.

> If we wanted to do it like we're pretending to be teachers ... then I think that we could have gone out to schools to see what the teachers actually did in the classroom and things like that, and then do our presentation at the staff meeting. (Interview with Zoe)

While the logistics of organising such assessment might prove to be unmanageable, it is a comment which reflects the student's belief that a real life context is an important component in learning.

Effective performers with acquired knowledge, and polished performances

The second characteristic of an authentic assessment, as defined in Chapter 3, is that students can be effective performers with acquired knowledge, and that they have the opportunity to craft polished performances and products. The students were required to complete both a performance and a report for the purpose of assessment. The students were very much aware that their presentations to the staff meeting and their written reports were for a specific purpose. For example, in the following excerpt, Carlo describes the process he and his partner performed in polishing the presentation, and relates the importance of approaching the task systematically and thoughtfully:

> It just makes you formalise all your results well so they are not all over the joint ... You have got your aim and then you've got why you are saying it and then you have your conclusion, so it helps you structure your answer better, and in the thinking of it as well. So you haven't got points all over the place. (Interview with Carlo)

Similarly, Debra pointed out the possible result if the performance is not planned and polished:

> You have to clarify your ideas, otherwise you're just going to sit there and babble. (Interview with Debra)

Louise was acutely aware of the purpose that the information she put into her report was to be put, and that it was information for a purpose. It would be used as the basis for the decision that the staff would take in adopting alternative assessment strategies:

> Just in a report ... you are not as much giving what you think is best, but more information for a purpose. So then the decision can be made. (Interview with Louise)

With the written report, several students felt that an essay, had it been set, would have allowed a lot more 'drivel' as opposed to the tighter requirements of an authentic report, and that if the information had not been required for a specific purpose 'we'd probably just regurgitate everything' (Interview with David). In commenting on the oral presentation, another student highlighted an important aspect of effective presentations, and how it is simply not enough to stand up before an audience and state the findings of the report:

> It made you put on a bit. You couldn't just say, this bit was good, this bit was bad. You had to try to sell it. (Interview with Glen)

The presentations to the staff meeting, and the written reports which were submitted later, were testament to the crafting and polishing that the students performed before the products were made public. All the presentations included the establishment of an authentic context, a persuasive argument to present the group's position, and the use of additional support material and evidence such as overhead transparencies and handouts. Similarly, all the written components of the assessment were completed in the format of a structured report including headings and tables, presenting an argument and recommendations, and all were either typed or desktop published.

Significant student time and effort in collaboration with others

A third characteristic of an authentic assessment is that it requires students to spend a significant amount of time on the task in collaborative groups. The issues of time spent on activities and collaborative effort have both been discussed earlier at length. However, the following comments and discussion relate to students' comments as they were answering questions about assessment, and draw an interesting comparison between authentic and traditional assessment, so it is useful to mention them briefly here. If an authentic assessment requires students to spend a significant amount of time and to work collaboratively with others, by definition it precludes the type of assessment which examines students individually with a 20 minute multiple-choice question test. One student, commenting on her view of traditional assessment, offered the following characteristics:

> I see traditional [assessment] as essays and anything to do with exams or tests ... something where you have only got a limited time and it is usually individual type work. (Interview with Evie)

The same student, comparing the authentic assessment used in the study with her view of traditional assessment, noted two important features:

> In this sort of assessment it allows you to develop more thinking and it is not as restricted. (Interview with Evie)

These comments, together with the substantial body of comments reported on collaboration earlier, suggest that an assessment based the total collaborative effort is more meaningful to students than an individual and separate assessment of student understanding at the completion of the activity.

Complex, ill structured challenges

The students were required to complete a task which was ill-defined. They were simply presented with two memos which depicted a problem and then a memo, requesting a plan for dealing with the problem. All the groups spent a considerable amount of time trying to determine what they were required to do. Students spoke about the difficulty of determining the requirements of the task. For example, one student found it to be 'quite a vague question'(Interview with Debra), and another spoke of not knowing where to begin or end. These comments indicate that considerable judgement is required within the task, to determine not only what response to give, but also its depth and scope.

The task appeared to be challenging to the students. Several students mentioned the fact that they felt more comfortable with more traditional forms of assessment, the essays and tests which are commonly used at this level:

> We haven't had that much of a chance of writing reports ... it scares us a little bit cause we don't really know what's expected. We probably would have felt a lot more comfortable if we did it as an essay but I think it is good that we're doing it as a report. (Interview with Zoe)

In spite of the apprehension which was apparent in all the students' comments about assessment, all responded well to the challenge.

Assessment seamlessly integrated with the activity

The fourth characteristic of authentic assessment defined in Chapter 3 is that the assessment integrates seamlessly with the activity itself. In the present study, the students worked on the multimedia program to investigate assessment strategies in mathematics classrooms, and to make a presentation to the class and submit a written report. It was upon these activities that the students were assessed. Students were not examined separately on their knowledge of assessment strategies in mathematics classrooms.

The integrated nature of the assessment and the task has made discussion of the two aspects of the research, as separate entities, quite difficult. The two overlap to such a degree, at times it has been impossible in the data analysis to code a student comment discretely into one section or another. This duality has not been lost on the students in their application of the assessment strategies used in the interactive multimedia program. For example, Rowan's comment on problem solving illustrates his belief that the strategy's use is so widespread and integrated into the teaching process that it is difficult to isolate it as an assessment strategy:

> Going back through my notes I wasn't too sure about some of the assessment strategies that they had down, whether they're actually assessment strategies ... I wouldn't call problem solving an assessment strategy. It's like a device you can use for assessment, but it really interacts with half of the others that they had there. (Interview with Rowan)

The students did not seem to be anxious or preoccupied with the thought that they were to be assessed on their work on the multimedia program. For example, Carlo commented on the fact that his group's attention was focused more purposefully on the task:

> We weren't really thinking of the assessment in the back of our heads. We were more worried about getting ... our thoughts basically without actually thinking 'Oh wow, we have got to present all this'. (Interview with Carlo)

When questioned about the value of a type of assessment which is closely tied to the use of the program, the students were generally very positive about it. Several students felt that such a close connection between activity and assessment meant that it was virtually impossible to 'regurgitate' information in a meaningless manner.

Multiple indicators of learning

The fifth feature of authentic assessment is that it provides multiple indicators of learning. The activity students completed, while using the interactive multimedia program on assessment, required them to examine the resource and submit a written report on their proposal, and to present an oral presentation to the staff meeting. The students appeared to be aware of the essential differences between this more authentic type of assessment and the kind they had experienced regularly over their school and early university life. For example, one student pointed out the lack of multiple indicators in a more traditional assessment approach:

> In traditional type assessment, they are usually asking you to read a whole lot of information, and marking you on how much you've read or how much you know ... you have got one question and you have got to answer it in the way you are told. (Interview with Evie)

Another theme which emerged with more than one student was the belief that there was a right and wrong way to answer a question, or to approach a problem. For example, Debra described the tension associated with sitting through other groups' presentations before her own:

> But you may be sitting there and someone goes before you and you go 'Oh my God, have we done it right or have they done it wrong?'.(Interview with Debra)

This study aimed to provide students with a variety of tasks which could be appropriately assessed with multiple indicators of success. The view that there could be a definitive right and wrong answer, even with an ill-defined and open-ended task such as the one the students had been given, is testament to the years of standardised testing that these students may have been exposed to. Such tests Wiggins (1990) points out, present students with objective items with one 'right' answer for each.

Validity and reliability with appropriate criteria for scoring varied products

In presenting these items for external scrutiny, each of the groups performed a variety of tasks, which needed to be assessed according to appropriate criteria. For example, the oral presentations to the staff meeting were judged by peer assessment using a pre-determined set of criteria including the effectiveness of the group's argument, the proposal's practicality, whether the arguments were well supported, and the group's presentation skills.

Students did not encounter any difficulties using the evaluation categories and appeared to apply serious consideration as they scored their colleagues' efforts. Not all students, however, agreed with the approach expressing the possibility that the procedure could be unfair. An examination of the results, however, showed a surprising consistency in scores across the groups. The validity of the task in relation to its authentic nature was summed up by one student who commented that:

> Group work was a good approach, since as a teacher we need to be able to work with other staff members. (Anonymous comment on unit evaluation sheet)

Summary of authentic assessment

The assessment used in this study used authentic assessment, as defined by seven critical characteristics, to assess students working on a sustained, ill-defined and complex activity in small collaborative groups.

The students appreciated the opportunity to be assessed in a real-life, if simulated, context. It was generally felt by the students that it was the kind of task they might be required to perform as teachers, and they saw it as good practice for that event. The form of assessment gave students the opportunity to be effective performers with acquired knowledge, and to present polished performances. Students had the opportunity to spend a significant amount of time of the project and the preparation of their response, yet interestingly most felt that the time allocation was insufficient.

In spite of the fact that some students expressed the view that they felt more comfortable with more traditional forms of assessment, such as essays and tests, they responded well to the complex and ill-structured challenge of the authentic assessment. The task the students were required to complete and the assessment of that task were integrated seamlessly into their working practice and provided multiple indicators to whether or not the students were successful in completing the task. Students were given the opportunity to use peer assessment on the presentations given to the staff meeting, and were given appropriate criteria for scoring performances. In spite of the fact that the suggestion was made that this process could be unfair, there was a surprising consistency in scores across the groups.

The findings of this study suggest that authentic assessment can be used successfully in interactive multimedia, albeit not encapsulated with the software itself, but as part of the learning environment.

Discussion

Patton (1990) points out that the analysis of qualitative data is 'heavily shaped' by the theoretical framework in which the study is conducted and this was borne out in the current study. The situated learning framework used for the design of the assessment program appears to be a successful model of instructional design for interactive multimedia learning environments.

The model was tested with second year university students who were assigned a large-scale, complex and ill-defined task ideally suited to the model. As Collins (1991) points out with regard to the cognitive apprenticeship model: 'If the targeted goal of

learning is a rote task, cognitive apprenticeship is not an appropriate model of instruction. Cognitive apprenticeship is a useful instructional paradigm when a teacher needs to teach a fairly complex task to students' (p. 45). These comments are equally applicable to situated learning as defined here, which appears to be an effective instructional paradigm when used to guide the learning of an appropriately complex task, described by Jonassen (1991b) as 'advanced knowledge acquisition' (p. 32).

One of the most surprising findings of the situated learning study was the important role collaboration plays in the situated learning model, not only in its own right, but as a vehicle for the operalisation of many other elements of the model. While it is acknowledged that individual construction of meaning is important in learning (Resnick, 1996), the role of the collaborative partnership appeared to provide a multitude of advantages for students working in complex learning environment. A number of researchers have described the difficulties of working collaboratively (e.g., Hooper, 1992 which are largely inter-personal problems), and while several students alluded to these types of problems, none was evident in the study. The findings suggest that students benefit from the opportunity to articulate, reflect and scaffold with a partner, and that they will seek these opportunities covertly if they are not available legitimately. Another surprising finding was the import that students placed upon the authentic context provided by the interactive multimedia program on assessment. The students' comments revealed their perception that university education is relatively impoverished of authentic context, where they are required to absorb factual information provided in a 'transmission' style of delivery largely devoid of any real life relevance. The students perceived a void between theory and practice, where theory was a relatively unimportant aspect confined to their university classes, and practice was the critical experience they received in professional practice in schools. The students appreciated the blurring of the two in the interactive multimedia program, where theory and practice were combined. The effectiveness of the authentic activity, in testing the students' previously used procedures for dealing with such activities, was another interesting finding. As Kroll, Masingila, and Mau (1992) have pointed out, the activity should 'present a new situation for which the students neither know an answer, nor have a previously established procedure for finding an answer' (p. 621). The activity used in the study was sufficiently complex, and sufficiently grounded in real life uncertainty, to challenge the students' regular procedures and 'sub-optimal schemes' for dealing with such problems.

The instructional technology field abounds with argument about the importance of interactivity (e.g., Laurillard, 1996; Sims, 1995; 1994; Schwier & Misanchuk, 1993;

Lockwood, 1992; Quinn, 1997) in particular, how instructional technologies can be designed to include interactivity between the program and the learner. The most interesting aspect of the findings of the current research was the capacity of the interrelated elements of the situated learning model to promote interactivity without the need to anticipate students' responses. The combination of authentic context, authentic activity and authentic assessment, and the collaborative arrangement of students into groups enabled students to reflect, to articulate, to assist with scaffolding, and to interact with the program and each other in the most meaningful of contexts. There was no need for the designer of the program to predict student responses in order to provide appropriate feedback (Sims, 1995); there was no need for students to be challenged by the program to engage in processes of 'application' and 'generation' (as suggested by Henderson, Patching, & Putt, 1994); there was no need for students to be prompted by the program to reflect or articulate to a friend (as suggested by Chee, 1995). The situated learning framework appeared to pre-empt the need for these interventionist strategies, lending tacit support for Reeves' comment: 'In the final analysis, deeper, richer levels of learning and human development may be better attained via fundamental changes in our pedagogical philosophy rather than by the tinkering of instructional designers with levels of "interactivity"' (Reeves, 1995a, para no. 11)

Miles and Huberman (1994) point out that qualitative researchers have no rich traditions to guide their analysis, and few guidelines on how to do it. They do, however, point out that in spite of the belief that there is no objective right and wrong, the researcher 'cannot escape the sneaky feeling that, in fact, reasonable conclusions are out there somewhere' (p. 262). The reasonable conclusions presented from this research are that the situated learning model is appropriate and effective for an interactive multimedia learning environment for advanced knowledge acquisition. Further studies, both systemic and analytic, should confirm these conclusions.

Higher-order thinking analysis and discussion

Many of the studies cited in Chapters 2 and 3 discuss the importance of engaging students in activities which require more than the simple application of rules and procedures. Collins, Brown and Newman (1989) contend that few educational resources (including interactive multimedia) are devoted to higher-order problem solving activities, and few activities require students to use cognitive and metacognitive strategies and processes.

While higher-order thinking might most simply be described as 'all intellectual tasks that call for more than information retrieval' (Baker, 1990), Lewis and Smith (1993) give a more comprehensive definition: 'Higher-order thinking occurs when a person takes new information and information stored in memory and interrelates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations' (p. 136). Ennis (1993) defines higher-order or critical thinking as 'reasonable, reflective thinking focused on deciding what to do or believe' (p. 180). These views form part of the abundance of literature on the nature of thinking, problem solving and reasoning. Chapter 2 describes in greater detail many of the studies which have produced methods and procedures to classify and define higher-order learning. However, as Newmann (1990) points out, each approach has its own persuasive rationale. He contends that it is not productive to try to choose the best, but more sensible 'to search for a common conception that embraces diverse emphases but which attracts professional consensus' (p. 42).

Chapter 4 describes the development of an interactive multimedia program which sought to enable students to engage in higher-order learning as they completed a complex, collaborative activity. Students were videotaped using the program and their discussion was transcribed for analysis. This section of the study investigates the extent to which students employed higher-order thinking as they used the program.

The chapter begins with a discussion of the methodology of the analysis of the data (the methodology of the data collection was described in Chapter 5). This discussion includes a description of the methodology used to refine and employ the instruments used to analyse data from the transcripts of the videotapes. A classification scheme

for analysing student talk is described. The analysis and discussion of findings follows.

Research question 3:

What types of higher-order thinking do students employ while using an interactive multimedia program based on principles of situated learning?

Framework for analysis

In order to answer the research question, it was necessary to record students' talk as they used the interactive multimedia program, and then transcribe and analyse that talk with the use of a classification scheme. While there is little option but to count talk as the outward representation of thought (and this is accepted in many of the studies described in this chapter, such as Marland, Patching, & Putt, 1992; Alexander & Frampton, 1994; Nastasi & Clements, 1992; Henri, 1992), doubt has been expressed about its usefulness. For example, Halliday (1985) has pointed out that academic discourse, in particular, can be disjointed and unlike everyday talk:

> When philosophers of language began recording speech they started with academic seminars, because they were easiest to get at: there is a lot of talk, the interactants tend to stay in one place, and they wouldn't object to being recorded, since no great personal secrets were likely to be revealed. But this is just the kind of discourse that is most disjointed, because those taking part are having to think about what they are saying, and work out the arguments as they go along. The ordinary, everyday exchanges in the family, the gossip among neighbours, the dialogue with narrative that people typically bandy around when sitting together over a meal or at the bar … these tend to be much more fluent and articulated, because the speakers are not having to think all the time about what they are saying. (p. 90)

This view is supported by Young (1995) who points out that 'think-aloud' protocols used with students often fail to enlighten researchers about problem-solving methods because at the point when the students are most engaged in problem solving, they become quiet, 'possibly due to cognitive workload and the invasiveness of having to say what one is doing and at the same time doing it' (p. 92).

Nevertheless, the social context of a situated learning environment to some extent vindicates the position that the students articulate their thoughts as they communicate

with one other in a meaningful way. Rather than 'thinking aloud' and articulating unnaturally and individually to a researcher, a social context means that the sharing of thoughts is critical to communication. As von Wright (1992) points out: 'The advantage of social contexts for learning is that they elevate thinking to an observable status' (p. 66), and it is the acceptance of this assumption that is the foundation of analysis of the higher-order thinking used by students in the study.

The framework for analysis and classification scheme were developed in two stages from data gathered in the pilot study and from the extensive literature on higher-order thinking. As noted by Henri (1992), there is no lack of analytical methods for the study of communication patterns. However, many of the methods used in the disciplines of psychology and linguistics, for example, are complex, highly-specific research tools which may have little relevance for the non-specialist, or enable little useful meaning to be drawn about the messages students convey as they use multimedia.

To be helpful, the framework chosen for the present study needed to encompass a view of higher-order thinking which is in keeping with research into both educational contexts and the use of new technologies, and be compatible with interpretive research methods. Several frameworks have been developed for analysis of student cognition within learning environments which serve as a useful starting point for the current study, although Frampton (1994) cautions that such frameworks inevitably have different features which may lead to different interpretations of meaning.

Marland, Patching and Putt (1992) analysed students' thought processes while studying distance education texts using stimulated recall video techniques. They classified 'mediating thought processes' into one of 19 data-generated categories, such as, *analysis, anticipation, comparing, confirming linking, metacognition, recalling, strategy planning* and *transformation*. Similarly, Alexander and Frampton (1994) used a non-hierarchical scheme which used an unspecified number of categories such as *read, infer, generate, plan, evaluate* and *conclude,* to categorise students' cognitions as they worked on an interactive multimedia program. Nastasi and Clements (1992) analysed social processes and higher-order thinking in group problem-solving in two different computer environments, using a 'behavioral coding scheme'. The scheme used indicators of 'social-cognitive' behaviour such as *collaborative, non-collaborative, peer as resource, teacher as resource, social conflict* and *cognitive conflict*. Clearly, the categorisation of spoken messages within learning environments is a practised format for analysis of student talk.

However, the work of Henri (1992) has been most useful in providing a model for analysis of the data in the study. Henri developed her framework for analysis of student talk in a computer-mediated conferencing environment. Student exchanges during lessons were monitored and analysed using content analysis. Henri and Parer (1993) claim that content analysis, 'when conducted with an aim to understanding the learning process, provides information on the participants as learners, and on their way of dealing with a given topic' (p. 451).

Content analysis, as used by Henri (1992), was characterised by a cognitive view of learning and used a framework of five *a priori* categories to analyse the social, psychological and cognitive dimensions of the exchanges: *participative, social, interactive, cognitive* and *metacognitive*. The emphasis content analysis places on the type of exchange observed between the student participants, together with its qualitative approach and its compatibility with the categories suggested by Resnick's (1987a) definition of higher-order thinking, meant that it was a useful organising framework for the classification scheme to be used in the study.

Development of the classification scheme

In order to classify students' talk as they used the interactive multimedia program on assessment, a table of indicators was prepared based on Resnick's (1987a) characterisation of higher-order thinking (described in detail in Chapter 2) drawing on a number of other researchers and theorists for corroboration. To simplify the classification for the purpose of the research, several of Resnick's characterisations were combined to enable more distinct categories to be drawn. Two versions of this scheme were used. The first version was an *a priori* list prepared for use with the data gathered in the pilot study. Analysis of the pilot study data revealed several inadequacies with this first scheme which made classification difficult. One or two categories appeared which did not fit neatly into the scheme, and other categories had no instances of talk assigned to them. McLoughlin (1996) points out that *a priori* categories can inhibit the use of categories occurring within the data. Clearer distinctions between the categories needed to be drawn which related more closely to the data. The second classification scheme was a refinement of the first. It was again, based strongly on Resnick's (1987a) scheme but was developed iteratively with the data from both the pilot study and the main study. It was more data driven rather than the first *a priori* list. It contained two essential differences from the first:

1. The first revised list, used in the pilot study, combined three of Resnick's characteristics to produce a category entitled *Non-algorithmic, complex and*

uncertain. It was decided to split this into two when it became clear that two quite different functions were included here. Expressions of uncertainty, together with plans for actions could usefully be separated into two categories for classification.

2. The first revised list had *Yields multiple solutions* as a separate category. In analysis of the data, no instances of this category were found which were sufficiently distinguishable from *Imposing meaning*. It was decided to combine these two categories for the purpose of refining the classification scheme.

The original characterisations, together with the two revised lists, are provided below in Table 8.1.

Table 8.1: Classification scheme of student talk including Resnick's (1987a) original characterisation and two variations used in the study

Resnick's (1987a) original characterisation of higher-order thinking	Revised characterisation of higher-order thinking for pilot study (a priori)	Final revised characterisation of higher-order thinking for classification of student talk
6. Higher-order thinking often involves *uncertainty*. Not everything that bears on the task at hand is known.	**Nonalgorithmic, complex and uncertain** The path of action is not fully specified in advance and is not 'visible' from any single vantage point. Not everything that bears on the task at hand is known	**Uncertainty** Not everything that bears on the task at hand is known.
1. Higher-order thinking is *nonalgorithmic*. That is the path of action is not fully specified in advance.		**Deciding on a path of action** The path of action is not fully specified in advance and is not 'visible' from any single vantage point.
2. Higher-order thinking tends to be *complex*. The total path is not 'visible' from any single vantage point.		
4. Higher-order thinking involves *nuanced judgement* and interpretation.	**Involves nuanced judgement and interpretation**	**Involves nuanced judgement and interpretation**
5. Higher-order thinking involves the application of *multiple criteria*, which sometimes conflict with one another.	**Multiple perspectives** Which sometimes conflict with one another	**Multiple perspectives** Which sometimes conflict with one another
8. Higher-order thinking involves *imposing meaning*, finding structure in apparent disorder.	**Imposing meaning and effortful thinking** Finding structure in apparent disorder. There is considerable mental work involved in the kinds of elaborations and judgements required	**Imposing meaning, effortful thinking and multiple solutions** Finding structure in apparent disorder. There is considerable mental work involved. It may yield multiple solutions, each with costs and benefits.
9. Higher-order thinking is *effortful*. There is considerable mental work involved in the kinds of elaborations and judgements required.		
3. Higher-order thinking often yields *multiple solutions*, each with costs and benefits, rather than unique solutions.	**Yields multiple solutions** Each with costs and benefits, rather than unique solutions	

Resnick's (1987a) original characterisation of higher-order thinking	Revised characterisation of higher-order thinking for pilot study (a priori)	Final revised characterisation of higher-order thinking for classification of student talk
7. Higher-order thinking involves *self-regulation* of the thinking process. It is not recognised in an individual when someone else 'calls the plays' at every step.	**Self-regulation of thinking** It is not recognised in an individual when someone else 'calls the plays' at every step	**Self-regulation of thinking** It is not recognised in an individual when someone else 'calls the plays' at every step

Newmann (1990) points out 'all higher-order challenges … need not manifest all of Resnick's criteria' (p. 45), and in keeping with this view, it was decided to draw up a list of indicators to enable each instance of talk to be assigned to one of the six characterisations. Table 8.2 presents each of the revised characterisations together with corroborating definitions from other theorists and researchers in the area. The final column of the table gives precise indicators of each of the characterisations to be used in the study to enable classification of the students' talk.

Table 8.2: Corroboration of characteristics of higher-order thinking and indicators for classification

Revised characterisation of higher-order thinking	Corroborating definitions of higher-order thinking from other theorists	Indicators for the purpose of classification
Uncertainty	Asking clarifying questions. (Ennis, 1993)	Any question or statement seeking clarification of requirements. Any statement expressing uncertainty.
Deciding on a path of action	Deciding what to do (Lewis & Smith, 1993) Browsing and searching (Duchastel, 1990)	Any statement referring to a suggested course of action. Any question asking opinion on a course of action.
Judgement and interpretation	Identifying conclusions, reasons and assumptions. (Ennis, 1993) Developing and defending a position on an issue. (Ennis, 1993) Defining terms in a way appropriate for the context. (Ennis, 1993) Making contributions which are relevant and connected to prior discussion (Newmann, 1990)	Any statement which seeks to defend a position taken on an issue Any statement which connects to, and furthers, the discussion Any statement which defines terms in a way appropriate for the context
Multiple perspectives	Angling (establishing different perspective) (Duchastel, 1990) Assuming the role of questioner and critic (Newmann, 1990)	Any statement which suggests an alternative approach. Any statement which challenges a conclusion or previously made point by providing an alternative perspective Any statement which challenges a perspective given in the interactive multimedia program

Revised characterisation of higher-order thinking	Corroborating definitions of higher-order thinking from other theorists	Indicators for the purpose of classification
Imposing meaning, effortful thinking and multiple solutions	Drawing conclusions when warranted, but with caution. (Ennis, 1993) Offering explanations for conclusions (Newmann, 1990) Deciding what to believe(Lewis & Smith, 1993) Solving a nonroutine problem(Lewis & Smith, 1993)] Integrating (interrelating conceptual elements) (Duchastel, 1990) Generating original and unconventional ideas, explanations, hypotheses or solutions to problems (Newmann, 1990) Creating a new idea, a new object, or an artistic expression (Lewis & Smith, 1993) Making a prediction (Lewis & Smith, 1993)	Any statement which states a conclusion. Any statement which offers a summary of the point of view adopted Any statement which states a belief or original perspective on the subject matter Any statement which proposes alternative solutions to problems Any statement which recognises that alternative approaches have different costs and benefits
Self-regulation of thinking	Applying metacognitive skills (Vockell & van Deusen, 1989)	Any statement which expresses an awareness of thinking processes or understanding Any statement or question which acts on awareness of thinking to affect a change

This classification scheme provided a workable tool for analysis of *Higher-order* student talk. It was also necessary, however, to draw up similar criteria for the classification of talk which could not be considered higher order. While this type of thinking was not a primary focus of the study, three sub-categories were used: *Social, Procedural* and *Lower order,* rather than have a simple category of *Non-higher order thinking*.

Social

It was inevitable that the students, as social beings, would devote some of their discussion to topics which were either totally irrelevant to their work on the assessment task, or to interactions which were on-task but more social rather than task-related. These social comments were divided into two groups: *Social off-task* and *Social on-task*. Both of these types of talk were evident in the discussion of the students

in the pilot study. Their descriptions and indicators are given below in Table 8.3, together with definitions from other researchers, as for higher-order learning.

Table 8.3:   Classification scheme of student talk: Social

Characterisation	Definitions of social interactions from other theorists	Indicators for the purpose of classifying
Social: off-task	Not related to formal content of subject matter (Henri, 1992) Irrelevant, but important communicative functions (McLoughlin, 1996)	Any statement which is off-task
Social: on-task		Any statement or question which is on task but relates more to the social interaction of the students than the task itself

Procedural

In completing the activity, it was possible that students would talk about the procedural aspects of the task. Three types of procedural statements or questions were used in the classification scheme—those relating to the equipment, the software and the content.

In order to use the multimedia program, students were required to use a variety of electronic equipment, such as a computer with CD-ROM drive, keyboard and monitor. Students also assisted with data collection equipment occasionally, such as turning over the tape in the cassette-recorder. It was likely that some of their talk would focus on the procedural operation of this equipment. Similarly, the assessment program itself (the software) required procedural discussion between the students who were required to negotiate the notebook facility, to scroll and click to select elements, and to operate the video and volume controls. Procedural discussion was also likely to arise as students decided the necessary requirements and format of the task. Each of these characterisations is summarised in Table 8.4 below, together with definitions and indicators.

Table 8.4: Classification scheme of student talk: Procedural

Characterisation	Definitions of social interactions from other theorists	Indicators for the purpose of classifying
Procedural: equipment		Any statement or question which relates to procedures of the equipment
Procedural: software		Any statement or question which relates to procedures of the software
Procedural: task	Dialogue involving information exchange on course requirements (Oliver & McLoughlin, 1997)	Any statement or question which relates to procedures of the task

Lower order thinking

It was necessary to include a category in the classification scheme which could embody the routine kinds of comments which people make in collaborative situations. These comments could include the simple application of a well learned rule, or comments which indicate little or no original thought, in other words, those that are 'unreflectively automatic' (Ridley, 1992). Many of these comments are, of course, procedural, but it was felt necessary to include this category to be able to classify the lower order comments which were not procedural. The characterisation of lower order thinking, the definitions from other theorists and the indicators are provided in Table 8.5.

Table 8.5: Classification scheme of student talk: Lower order thinking

Characterisation	Definitions of social interactions from other theorists	Indicators for the purpose of classifying
Lower order thinking	Demands only routine, mechanistic application of previously acquired knowledge (Newmann, 1990)	Any statement which applies a previously learned rule Any statement which is a simple statement of fact or reaction requiring little thought

All student talk was classified according to the scheme described above. The scheme is represented diagrammatically in Figure 8.1.
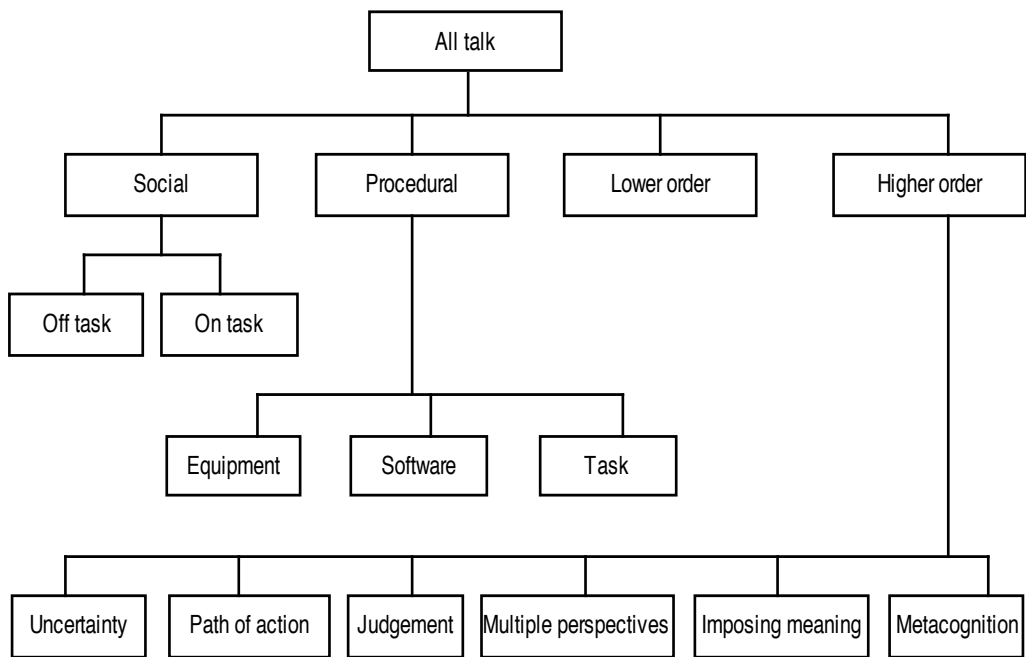
Figure 8.1:   Flow chart of classification scheme of student talk

The unit of analysis

In order to assign student talk to a category, it was necessary to define the 'grain size' of the unit of speech to be classified. Analysis by individual words, while used in some research using discourse analysis, was not considered to be necessary or useful in the present study which was to focus much more generally on themes discussed rather than the individual words used. Several options remained. Talk could be divided into passages of dialogue, single utterances (each one's turn at talk) or units of meaning.

Each of these units of analysis has limitations. For example, in Table 8.6, a passage of dialogue is given which has been counted according to the three methods described. In Method 1, the whole passage has been counted as one instance of *Path of Action*; in Method 2, each students' turn at talk has been assigned predominantly to a single category; and in Method 3 each instance has been assigned as it occurred as a unit of meaning, which means that some students' turn at talk might be classified in more than one category. The totals of each count are given at the bottom of the table.

Table 8.6: Three different results from using different methods of counting categories of talk

Passage	Method 1: Count passage	Method 2: Count utterance	Method 3: Count units of meaning
R: OK samples. Questioning, this is the important bit at the moment. Which bit?	Path of action	Judgement	Judgement Uncertainty
C: That bit, that whole block.		Path of action	Path of action
R: See they're saying—what is it, they haven't used the word—don't ask closed questions, ask what are they called? Ask, um ...		Uncertainty	Uncertainty
C: Open questions?		Uncertainty	Uncertainty
R: Yes but there's a word, so they're saying higher-order questions but. Oh I've got a blank. So I'd say if you ask a question that needs more than a 'yes'. So just that bit from there?		Judgement	Judgement Metacognition Path of action
C: It's copying straight away again.		Procedural-software	Procedural-software
R: So we need samples.		Path of action	Path of action
C: Should we copy down one or two of those examples?		Uncertainty	Uncertainty
R: No we can do those.		Path of action	Path of action
C: Will we look at the video on that?		Path of action	Path of action
R: Yes, the scenario at least. And we'll see what the student says. We know what the teacher would say.		Judgement	Judgement Path of action Metacognition
Count of classification	Path of action 1	Procedural-software 1 Uncertainty 3 Path of action 4 Judgement 3	Procedural-software 1 Uncertainty 4 Path of action 6 Judgement 3 Metacognition 2

Each of the methods demonstrated above in Table 8.6 was considered for use in the study.

Method 1: Division by passage

A common approach used in research of this type is to divide the dialogue into passages and assign each passage to a single category. Wild and Braid (1995) point out that this is sometimes necessary when the speakers each contribute to the meaning, where one may start the sentence and the other finish it.

However, as can be shown in the example, the categorisation of the talk into passages (Method 1 in Table 8.6) is extremely difficult. Where does one passage end and another begin? Is every utterance to be counted, or simply those that fit into a classifiable passage? Is there ever any overlap? Division into passages must inevitably become arbitrary. Another problem with this approach was that at times, each student in the pair would talk in parallel in different categories for a short time. For example, one student might begin by using *Judgement*, the partner may respond with *Uncertainty* or *Multiple perspectives* before they both use anecdotes or arguments to *Impose meaning*

Such difficulties associated with this method precluded the use of the approach in the study.

Method 2: Division by utterance

Each student utterance, (that is, a comment by a student before the other student speaks, or a turn at talk) was also considered as a unit for classification and this was used for the first analysis of the pilot study data. This approach worked quite well, as generally each student remained within a single category in a single utterance. However, there were a considerable number of times when a student might use more than one type within a turn at talk. If instances of types of talk were to be counted, simple counting of the category detected most predominantly in the comment could give a wrong impression of the relative frequency of each type.

In the example given in Table 8.6, Method 2 gives a much clearer indication of the types of higher-order thinking that are occurring as students use the program than Method 1. However, the necessity to constrain the classification to the most predominant one in the utterance means that some types of thinking might not be counted at all.

Method 3: Division by unit of meaning

The third method considered was to count each instance of a type of talk as it occurred, (Henri, 1992) and this meant that while the majority of utterances were counted only once, some were counted up to five times in different categories. This method enabled the detection of types of talk which may have been neglected by the other methods. Notice that the use of Method 3 in Table 8.6 revealed two instances of metacognition which were missed using the other two methods.

It was decided to use the *Unit of meaning* as the unit for analysis of data collected in the study.

Analysis of student talk

In analysing the student talk, no attempt was made to interpret non-verbal aspects of the students' communication, or to analyse linguistic features such as stress, intonation, pitch, pronunciation, or the roles of individuals as producers or recipients of talk (Langford, 1994). Using the unit of analysis of each *unit of meaning* as described above, each instance of a type of talk from the transcript of the videotapes was assigned to a category. The comments were assembled by category using the qualitative analysis package (NUD•IST) for analysis, but they were also kept in chronological order to enable the context of the comment to be investigated further if necessary.

One particular aspect of classification of talk required a specific reliability check to ensure that some confidence could be held in the numerical data relating to students' use of higher-order thinking as they used the multimedia program. Miles and Huberman (1994) recommend 'check-coding' as an aid to definitional clarity of codes and also as a good reliability check. Check-coding is a means of ensuring that a number of different coders agree on the codes to be assigned to units of data, described by Patton (1990) as 'a form of analytical triangulation' (p. 383). While all the coding, in this study, was performed by a single researcher, check-coding was considered a useful procedure as a reliability measure generally. In this exercise, every instance of students talk while using the program was categorised into one of the types of pre-determined category of talk, rather than simply categorising them by issue or theme. It was essential to have some measure of reliability on the assigned codes.

Following a procedure outlined by Miles and Huberman (1994), 8 pages of the video transcripts (the first 2 pages of the transcript for each group of students) were coded independently by two separate researchers (university academics). In order to do this, the researchers were given a description of each category, together with a working definition, and an example of the student talk considered to be a clear example of the category (see Table 8.8). Reliability was calculated using the following formula (Miles & Huberman, 1994, p. 64):

$$\text{Reliability} = \frac{\text{Number of agreements}}{\text{Total number of agreements + disagreements}}$$

Miles and Huberman (1994) recommend aiming for a coding consistency of 90%, and that this can be achieved by separate coding exercises reviewed together by coders. Clarifying any differences in assigning codes, and the sharing of insights, can bring initial reliability rates of less than 70% to 90% or better. The exercise was completed by

having the two coders complete the first round of the exercise in isolation. The second round was done in collaboration with the researcher to isolate any misunderstandings or problems. These discussions were very fruitful in identifying potential problems with the coding system prior to its use on the whole body of data by the researcher. Most of the disagreements were resolved by tightening definitions of instances and by explaining misunderstandings created by coding the written word rather than the more contextually-rich video record. Table 8.7 shows the reliability figures obtained in the first and second rounds of exercises.

Table 8.7:   Reliability of coding

	Coder 1	Coder 2
Round 1	77%	67%
Round 2	94%	93%

By the conclusion of the second round, the reliability between the researcher and the two coders was sufficiently high to assume some confidence in the coding process.

Summary of classification of talk

All types of talk were evident in the students' talk as they used the interactive multimedia program on assessment, although not necessarily in each group. Each category of talk, together with a definition, a short summary and example of type is given in Table 8.8. Each category, is then discussed in greater detail following the table.

Table 8.8: Summary chart of classification of student talk

Category	Sub-category	Definition	Summary of student talk	Example of type
Social	Off-task	Any statement not related to the subject matter	There were very few instances of off-task social talk. This may have been because the students were conscious of being videotaped.	G: We got caught in a traffic jam ... We didn't see it happen but we saw a van, the side of it was all smashed in.
	On-task	Any social statements which relate in some way to the task	The main use of this type of talk by students was teasing between the partners, or comments when students recognised some of the teachers in the video clips.	C: Hey I know this guy ... He was my teacher. What a spin. I wonder what he is doing. I can't remember his name.
Procedural	Equipment	Any exchange of information related to the equipment (such as the operation of the computer, monitor, keyboard, CD-ROM drive etc.)	There were a number of comments in this category generally occurred in discussion centred on saving the contents of the notebook to disk, or setting the volume level from the control panels of the Apple menu.	R: No you won't have a volume on this ... it'd be on the Apple menu. You have to go into systems folder then control panel.
	Software	Any exchange of information related to the software (any functional aspect of the assessment program itself)	These comments related mainly to problems with sound levels within the program or unexpected results when the students were using the notebook.	C: That didn't work. R: Did you push copy first? C: I'm rushing it. Here we go. Wiped it.
	Task	Any exchange of information related to the task (the formal requirements of the oral or written report).	Almost all the comments classified under this heading related to the requirements of the task the students were given, and the form the report had to take.	G: Are we actually supposed to prepare this as a report to staff? D: No, I don't think so. I think we prepare our notes and then just say it.
Lower order		Any student talk which is routine, requiring little thought, or the mechanical application of well known rules.	Comments in this classification included many routine kinds of questions and statements about the task.	C: You are missing an r in strategies. R: They are playing dominoes. It is a little primary school class.
Higher order	Uncertainty	Any student talk which involved deciding on an approach to adopt, suggesting a course of action, or any expression of dilemma or uncertainty.	Generally, this talk involved uncertainty about which elements of the program to access, the order of viewing, and uncertainty about the content or ideas being expressed in the program.	L: So really we want to look at all of them don't we? E: OK do you want to start putting anything into our notebooks? L: Like what?
	Path of action	Any talk which involved decisions about which elements of the program to access, decisions about what to save in the notebook and negotiations on how to proceed.	Comments in this classification were generally found when students stopped to negotiate the order of viewing of the various media elements in the program, and when they were deciding upon a course of action to accomplish the task.	R: We should go right through the whole lot again. We need to make more notes on it.

Category	Sub-category	Definition	Summary of student talk	Example of type	
Higher order	Judgement	Any statement or question which referred to students' attempts to interpret and defend their understanding of the issues presented in the assessment program.	The students used this kind of talk as they probed more deeply into the requirements of the task and attempted to put together a response.	G:	If you're going to do anecdotal records on all the kids ...
				D:	You wouldn't carry them around. You'd make notes and put them in later.
				G:	That's the whole point of having them combined.
	Multiple perspectives	A statement or question was classified in this category if it suggested an alternative approach or challenged a conclusion, or previously made point, by providing an alternative perspective.	Such challenges need not be vigorous or argumentative, and the students in the pilot study frequently challenged each other, and sought to apply different perspectives, as they completed the task.	R:	OK investigations, factual ... Ah, factual, factual recall, rote learning.
				C:	No, it's not saying you learn everything by rote, it's just saying that some-times you want students to respond automatically..
	Imposing meaning	Talk was classified into this category if it referred to a possible solution to a problem or suggested alternative solution, if it ex-pressed a decision about what to believe, or the creation of a new idea, or if it drew cautious conclusions.	This talk was generally observed when students were drawing conclusions about each section of their report, and in discussion about what their recommendations were going to be when they gave their report at the 'staff meeting'.	G:	Obviously we can intro-duce all of the strategies but not to start with. I think in the lower primary you probably can't expect them to do a mathematical investigation, so if they start out with oral work in the lower school and work towards doing the written ones in the upper school.
	Metacognition	Any comments which showed that students were aware of their own thinking and performance, and comments related to the use of this awareness to improve performance.	Students made many admissions that they were unsure or didn't know how to respond in certain circumstances. There were also many situations where the students used awareness of their thinking to act.	G: E:	What was that? I didn't get any of that. I don't know what to do. Where is that piece of paper I had before? [The activity].

The findings of the analysis are given in the following section in the order presented in Table 8.8. Findings, and the trends they suggest, are given together with examples of the students' dialogue as they used the assessment program. In some cases, more than one instance or utterance is provided to enable the reader to grasp the context of the comment rather than view it as an isolated statement (Cobb & Whitenack, 1996). However, in the majority of cases all the dialogue provided is of the type under discussion.

Social

The social talk of students as they used the interactive multimedia program on assessment was classified as being either off-task or on-task.

Off-task

Off-task talk was very easy to recognise as it was defined as being totally unrelated to the subject matter under discussion. The frequency of talk categorised as Social off-task by the four groups of students is presented in Table 8.9. Group 1 is from the pilot study; Groups 2–4 are from the main study.

Table 8.9:   Instances of talk categorised as Social off-task

	Group 1: Debra & Glen	Group 2: Evie & Louise	Group 3: Rowan & Carlo	Group 4: Zoe & David
Number of units of meaning	5	0	17	4
Percentage	3%	0%	5%	2%

There were relatively few examples of off-task social talk exhibited by the students as they used the multimedia program on assessment. An example of this type of talk was when one student explained to the other about an accident he had seen on his way to the university that morning:

> Glen: We got caught in a traffic jam. There was an accident ... We didn't see it happen but we saw a van, the side of it was all smashed in.
>
> Debra: Was anybody hurt?
>
> Glen: Yes, there was somebody in the ambulance when we got there and they were just putting another lady in. I think she was in shock ...
> (Observation of Debra and Glen using multimedia program)

The other instances of off-task social talk were isolated statements such as: 'I got a letter from Barney!' or 'I need food', or the occasional discussion of other university work from different units of study. The limited occurrences of off-task talk may not be a true indication of the usual level of such dialogue in similar situations. One student pointed out in the interview that she acted differently while being videotaped:

> Of course they [the school students in the video clips] are going to act in front of a camera, like we even acted differently in front of the camera. At one stage ... I turn around and go 'I got a letter from Barney'. I didn't realise we were being taped, I went 'Oh no'. (Interview with Zoe)

Another student made the point that he and his partner were always aware of the fact that they were being videotaped and that this may have influenced the purposefulness of their behaviour:

> I think that possibly because we were on video as well, we kept on task more.
> (Interview with Glen)

Clearly, the incidences of off-task social talk were limited by the presence of the data collection equipment, which inhibited the students' natural social interactions and encouraged them to stay on task.

On-task

On-task social talk was harder to recognise as it could easily be confused with one of the other content-related classifications such as *Procedural-task*. However, there were certain exchanges which were clearly related more to the personalities of the students as they attempted to establish their working relationship than to the task they were attempting to perform. The frequency of Social on-task talk by all groups is given in Table 8.10 below.

Table 8.10: Instances of talk categorised as Social on-task

	Group 1: Debra & Glen	Group 2: Evie & Louise	Group 3: Rowan & Carlo	Group 4: Zoe & David
Number of units of meaning	6	0	14	10
Percentage	3%	0%	4%	4%

The following exchange, and others like it, show how the students teased each other in a social manner:

Glen: You'll know what that means when you go to explain it.

Debra: When you go to explain it, you'll know ... You can do it.

Glen: That's not very nice.

Debra: Let's get back to this before you get yourself into trouble. (Observation of Debra and Glen using multimedia program)

The exchange, while social, is still very much on-task as it relates to the presentation of the report and it is unlikely that these particular students would talk to each other in this manner in a context unrelated to the work setting, such as if they were talking in the cafeteria or corridor.

Other instances of on-task social talk occurred during the students' use of the interactive multimedia program, such as playful disputes over which of the partners would use the mouse or the keyboard. One unexpected type of off-task social talk which occurred at least six times in the students' discussion, was the recognition of some of the teachers in the scenarios. When it happened, the student who recognised

the teacher explained to his or her partner the relationship with the teacher. For example:

Carlo: Hey I know this guy ... He was my teacher. What a spin. I wonder what he is doing. I can't remember his name.

Rowan: Which one?

Carlo: The one doing modelling. We get to see him now, the teacher, the man. (Observation of Carlo and Rowan using multimedia program)

Interestingly, one group had no instances of social talk. This group of two female students had not worked together before, and their talk was quite different to the other groups. They were very polite to each other and spent a considerable amount of time achieving consensus on how to proceed. They knew little about each other and did not use any of the time they worked on the interactive multimedia program to get to know each other better. The remaining groups spent a consistent proportion of the time in social on-task talk which was generally characterised by repeatedly engagement in interactions where they teased each other in a good-natured way.

Generally, there was less reluctance among most groups to engage in on-task social talk than off-task. It appeared to occur more naturally as a result of the task the students were performing, and students in three of the four groups were less inhibited in talking in this manner in front of the camera.

Procedural

Procedural talk between students was defined as any exchange of information related to the task requirements, and was classified as pertinent to the equipment (such as the operation of the computer, monitor, keyboard, CD-ROM drive etc.), the software (any functional aspect of the assessment program itself) or the task (any formal requirements of the report the students were to give to the class).

Equipment

The frequency of procedural-equipment talk by students is given in Table 8.11 below.

Table 8.11: Instances of talk categorised as Procedural-equipment

	Group 1: Debra & Glen	Group 2: Evie & Louise	Group 3: Rowan & Carlo	Group 4: Zoe & David
Number of units of meaning	0	10	9	13
Percentage	0%	4%	3%	5%

Some of the comments relating to procedures of the equipment related to the characteristics of the computer equipment used to play the multimedia program. For example, one group of students discussed the attributes of the computer they were working on:

> It is only 66 megahertz. Is it really? They still run quite well. (Observation of Rowan using multimedia program)

The most frequent type of comment appropriate to this category was the many statements and questions students made as they attempted to come to grips with the computer technology. This talk generally occurred in discussion centred on saving the contents of the notebook to disk, or setting the volume level from the control panels of the Apple menu. For example, the following non-sequential comments were classified in the category of *Procedural-equipment*.

> No you won't have a volume on this ... it'd be on the Apple menu. You have to go into systems folder then control panel.
>
> The cord's getting stuck.
>
> This mouse is really annoying.
>
> It wasn't my fault. It was the computer's.
>
> Push it back in. You might have to eject it first.

The fact that the programs were loaded and ready to use at the start of each of the students' work sessions may have reduced the number of equipment-related procedural comments. Nevertheless, such talk did occur as students used the multimedia program and it was not centred exclusively at any stage of use, such as at the beginning or end, but occurred throughout.

Software

The students in the pilot study made several comments relating to the operation of the software. The frequency is given in Table 8.12.

Table 8.12:   Instances of talk categorised as Procedural-software

	Group 1: Debra & Glen	Group 2: Evie & Louise	Group 3: Rowan & Carlo	Group 4: Zoe & David
Number of units of meaning	4	38	38	34
Percentage	2%	16%	12%	14%

Many of the comments categorised as *Procedural-software* were questions and statements about the operation of the media elements in the program as the students gained an appreciation of the limitations and possibilities of the software. Such comments were frequently in the form of a question, such as the following:

How do you get to the next page?

Did you push *Copy* first?

Do you want me to see if I can paste?

Does it matter how much you have in the notebook already?

On a positive note, the students expressed excitement on many occasions when they realised the capabilities of the program. For example, one student did not seem to realise at first that there were many scenarios, and that these could be accessed through the scrolling bar on the whiteboard:

Oh we can scroll. Oh there is heaps. ... Mega! So this is a massive, massive database. (Observation of Carlo using multimedia program)

Other students expressed interest and excitement in the ability of the notebook to save their notes for future use.

However, the students were also vocal in pointing out the shortcomings of the software. There were two or three problems with the notebook which had not been present during the pilot phase of the study or during formative evaluation of the software, but which were inadvertently introduced into the version used in the main study. For example, when students accessed the notebook to paste some material they had copied, the entire contents of the notebook would be highlighted. Students had to

click at the end of the notes, effectively deselecting the contents, before pasting the copied material. If students pasted without doing this, the entire contents were replaced. There were many comments which revealed how annoying this was for the students as they used the program. The following sequence was typical, albeit more decorous, of the dialogue that occurred on this point:

> Carlo: That didn't work.
>
> Rowan: Did you push copy first?
>
> Carlo: I'm rushing it. Here we go. Wiped it.
>
> Rowan: Now we won't have kept that ...
>
> Carlo: [To lecturer] How do you do this pasting business. It keeps wiping it out. (Observation of Carlo and Rowan using multimedia program)

There were a variety of comments from the students which pointed out other shortcomings in the program, problems which, if possible, were corrected before the software was released for use. For example, the students also commented on missing characters ('Oh [expletive] this is annoying'), spelling mistakes ('That is shocking!'), and problems with copying across columns ('This really bugs me').

Interestingly, students also began to see patterns in the way the procedures worked, and began to discover ways to use the software more efficiently. For example, one student complained about the fact that there was little intrinsic feedback that a command had been executed, but after more practice the other student in the group claimed to see a relationship between the length of time the text was highlighted and how much space there was in the notebook. Another student discovered that you could use the up and down arrows on the keyboard to quickly move around in the notebook, and this discovery was circulated among the groups.

All the groups had instances of software-related procedural talk. Two bugs which had crept into the software since the pilot study seemed to be the source of many comments of this type for the three groups in the main study. Generally, however, the students did not allow any software-associated problems to impede their investigation of the resource and quickly moved on to other matters.

Task

There were a number of comments which related to the task the students were given in a procedural manner (Table 8.13).

Table 8.13:   Instances of talk categorised as Procedural-task

	Group 1: Debra & Glen	Group 2: Evie & Louise	Group 3: Rowan & Carlo	Group 4: Zoe & David
Number of units of meaning	18	6	3	7
Percentage	10%	3%	1%	3%

These comments almost exclusively concerned the form the presentation and written report had to take. For example, the students in the pilot study were unsure whether they had to present the report solely in an oral form, or as *both* oral and written for dissemination to the other 'staff members'. For example, in this discussion, the students try to work out between them the requirements of the task:

Glen: Are we actually supposed to prepare this as a report to staff?

Debra: No, I don't think so. I think we prepare our notes and then just say it.

Glen: I know but we could get up as if we were getting up in a staff meeting ...

Debra: And say 'Here's your report. Thanks very much.' (Observation of Debra and Glen using multimedia program)

It is interesting to note the reduced number of utterances of this type in the main study, Groups 2, 3, and 4, where the requirements of the written and oral presentation to the class were specified. Much more time was spent by the pilot study group in defining whether the task was to be given to the staff meeting in an oral or written form. This problem was rectified by the time of the main study from the information gained from the pilot group.

The groups in the main study were clear about the necessity to present both an oral and a written report, but there were a limited number of comments which could be categorised as procedural relating to the content of the program. For example, the following comment was typical:

Yes, it says what you have to do here. It says you have to prepare a report on alternative assessment. (Observation of Louise using multimedia program)

However, the majority of comments in this category were little more than fleeting references. Students quickly moved from this procedural category, where they commented briefly on the requirements of the task, to higher-order categories such as *Uncertainty* or *Path of action*, where they set about determining how they were going to approach the task. Consequently, the comments categorised in this section were basic, perfunctory statements and questions relating to the task.

Lower order

Comments classified under this heading included the many routine kinds of questions and statements people make to each other when working together. Generally, there were relatively few instances of lower order thinking detected in the observation of the groups as they used the interactive multimedia program on assessment. In a sense, the category enabled the classification scheme to 'catch' routine kinds of comments not specifically related to procedural aspects of the study, which were categorised separately.

Table 8.14:   Instances of talk categorised as Lower order

	Group 1: Debra & Glen	Group 2: Evie & Louise	Group 3: Rowan & Carlo	Group 4: Zoe & David
Number of units of meaning	7	15	14	6
Percentage	4%	6%	4%	3%

Examples of lower order talk include the following non-sequential statements:

> Yeah. Just put in a dot, no put in a square.
>
> You are missing an r in strategies.
>
> They are playing dominoes. It is a little primary school class.
>
> No that's a plus sign.
>
> We're up to the next one now.
>
> OK we're finished.

The limited number of instances classified under this category seems to indicate that students did not constrain themselves to routine, mechanical, or unthinking comments, and quickly moved their discussion about assessment into the area of higher-order thinking.

Higher order

As described above, higher-order thinking was seen to be characterised by one or more of six types of talk, based on Resnick's (1987) characterisation of higher-order thinking: *Uncertainty, Path of action, Judgement, Multiple perspectives, Imposing meaning,* and *Metacognition.* The categories are broad definitions only, and cannot be considered discrete or mutually exclusive. Each of these classifications, and the types of student talk which fitted into each, is discussed below.

Uncertainty

Any expression of dilemma or uncertainty was classified into this category. Generally, this talk involved uncertainty about which elements of the program to access and the order of viewing, and uncertainty about the content or ideas being expressed in the assessment program. Table 8.15 indicates the frequency of this talk for each group.

Table 8.15:   Instances of talk categorised as Uncertainty

	Group 1: Debra & Glen	Group 2: Evie & Louise	Group 3: Rowan & Carlo	Group 4: Zoe & David
Number of units of meaning	33	61	37	30
Percentage	20%	26%	12%	13%

Students regularly expressed uncertainty about which elements of the program to access. The following were classified in the *Uncertainty* category as an example of the way the students were very uncertain in their negotiations with each other in how to proceed:

Louise:	So really we want to look at all of them don't we?
Evie:	OK do you want to start putting anything into our notebooks?
Louise:	Like what?
Evie:	Well for the anecdotal record do you want to put in like the description and say their sample? We don't really need the reflections of the student teacher do we?
Louise:	We don't really need those either do we? We could just come back and what we could do is, we could write our own notes on this and just take out little bits. You can actually copy and paste them can't you? (Observation of Evie and Louise using multimedia program)

Notice that in this exchange, the majority of utterances are questions. Questions are answered with questions. It is only after this initial uncertainty that concrete suggestions are made on the course of action to be adopted.

It is arguable that many of the comments which could be classified as *Uncertainty* might also be classified as *Metacognition*. For example in the following example, the first two questions are *Uncertainty*, but the third statement, while an expression of uncertainty is better classified as *Metacognition*, particularly in the light of the resolve to action in the fourth statement:

Shall I put this down for higher-order questions? Anything else? I don't know what to do. Where is that piece of paper I had before? [The activity]. (Observation of Evie using multimedia program)

Another common expression of uncertainty was with the issues and concepts presented in the assessment program. Students may have been uncertain about what the teacher or student or expert was saying. Again many of these comments were possibly metacognitive and a distinction was made for the purpose of classification. If the student simply made a comment such as: 'Why's it called open?', 'What is she doing?', 'Anecdotal. Is this part of the checklist thing?', it was classified as *Uncertainty*. If the student included his or her own awareness that they didn't understand by using the word *I* or *we*, the expression was classified as *Metacognition*, for example, 'I don't know what he's on about'.

As might be expected, uncertainty was a characteristic of much of the dialogue between the students as they used the assessment program, and was not confined to particular times.

Path of action

Talk was classified in this section if it involved decisions about which elements of the program to access, decisions about what to save in the notebook and negotiations on how to proceed. Comments in this classification were generally found when students paused to negotiate the order of viewing of the various media elements in the program, and when they were deciding upon a course of action, or the best approach, to accomplish the task. Frequencies of talk are given below in Table 8.16.

Table 8.16:   Instances of talk categorised as Path of action

	Group 1: Debra & Glen	Group 2: Evie & Louise	Group 3: Rowan & Carlo	Group 4: Zoe & David
Number of units of meaning	25	59	37	28
Percentage	14%	25%	12%	12%

As they used the multimedia program on assessment, the students frequently stopped to negotiate the order of viewing of the various media elements in the program, and often alternated between uncertainty and decisions on what to select. Deciding upon a course of action to follow, as shown in the following example, illustrates the complexity of the task and the fact that there is more than one course of action open to

the students. In this example, the students first decided upon what to copy into the notebook, and then decided to paraphrase their findings rather than copy whole sentences directly from the program each time:

> Evie: OK, so we go back to checklists, OK, so we highlight that part, highlight the attributes.
>
> Louise: Let's go back to the beginning and get that bit ... we can just go into the notebook and just write what we have said there instead of doing it word for word. I will just put understanding of particular concepts. (Observation of Evie and Louise using multimedia program)

One group of students spent a considerable amount of time reading the activity memo and trying to negotiate a course of action for the completion of the report. For example, in the following example, one student explored different ways of approaching the task and decided to group the strategies presented in the video clips into broader categories:

> Basically what we want is 3 dot points: Strategy ... I'd say do each of the strategies, because that's what it tells you and you can go with whatever video thing takes your heart. (Observation of Glen using multimedia program)

There were a number of other comments classified in this section which indicated that a suggestion or decision had been made about the best way to approach the task and accomplish the goal. For example, the following non-sequential comments are examples of these decisions:

> We should make comments on every one we have seen.

> Just condense it a bit.

> You can mark them in the notebook as we go through.

> We should go right through the whole lot again. We need to make more notes on it.

Talk in this category was observed frequently as students used the assessment program, and it was evenly spread throughout the whole session. The need to discuss the best course of action generally occurred at regular intervals and was not something which appeared at the beginning of the session and disappeared as students got underway. The collaborative nature of the activity may have contributed to this need to jointly decide on each course of action at the appropriate time.

Judgement

This category of talk was defined as any statement or question which referred to students attempts to interpret and defend their understanding of the issues presented in the assessment program (Table 8.17).

Table 8.17: Instances of talk categorised as Judgement

	Group 1: Debra & Glen	Group 2: Evie & Louise	Group 3: Rowan & Carlo	Group 4: Zoe & David
Number of units of meaning	33	27	60	50
Percentage	19%	11%	19%	20%

The students used this kind of talk as they probed more deeply into the requirements of the task and attempted to put together a response. For example, in the following discussion, two students discussed the benefits of using anecdotal records as an assessment strategy. They realised at one point that everything they had listed is positive and they tried to think of some disadvantages of using the method. In so doing, they interpreted the value of the strategy and sought to apply some judgement on when it may be beneficial to use it:

Debra: This 'not enough information' is not true. It's only if you look at checklists by themselves ... Anecdotal records. It's all positive.

Glen: For an anecdotal record by itself though, its like you end up carrying around files and files.

Debra: 'I've got it here somewhere' [pretending to look through a huge pile of files]

Glen: They can be boring as well.

Debra: Too much information.

Glen: Too cumbersome...

Debra: What's cumbersome mean? Sounds good. Too much?

Glen: No it just means too much to carry around - excess baggage ...

Debra: But you wouldn't carry them around. You'd make the notes and put them in later.

Glen: You'd make the notes on your checklist. That's the whole point of having them combined. (Observation of Debra and Glen using multimedia program)

The explanation, provided by one of the students in this passage, of the definition of the word 'cumbersome' is a typical example of defining terms in a way appropriate for

the context (Ennis, 1993). Similarly, the following explanation of a structured interview helps the student understand the relevance of the video scene on *Structured interviews*:

Glen: Can I ask, what's that got to do with structured interviews?

Debra: Well the structured interview is like if the person's having trouble with that question, then you ask them questions about the question. (Observation of Glen and Debra using multimedia program)

Most of the interactions between the students which were classified into this category were of this nature, and there were a substantial number.

Students working on the assessment frequently related their own experiences and anecdotes to each other in response to events and sequences they observed in the multimedia program. These anecdotes and stories were categorised into the *Judgement* section as they were seen as attempts by students to judge and interpret the meaning of the new information and to incorporate it into their existing understanding of the issues. For example in the following excerpt, the students have watched a scenario on pencil and paper tests where the teacher discusses with a small group of students their answer to a test item on the numbering system used by 'Martians' and how it might be interpreted. One student related the scenario to his own experience in two ways: by comparing the method used by the teacher to a similar technique he has used as a tutor, and by relating his own knowledge of the problem, and the mathematics required to solve it, to the students' responses in the video. Finally, the student made a judgement on the item itself. He concluded that it is not a routine pencil and paper test item, and that it had been used in a much more innovative and meaningful way than is typically the case:

I do that when I work with the kids that I tutor with, I get them to explain the question, explain how they go about getting to there, explain how they did it and then what they thought of the question in the first place ... 'Oh I remember that that's an old one' [referring to one of the problems on the video]. I treat it like roman numerals [one of the students on the video says 'Yes roman numerals']. That's right. You would have to have prior knowledge you would have to know how roman numerals worked. You would have to know how roman numerals represented numbers ... But that wasn't the way you normally think of pencil and paper they weren't just doing it on paper, they were talking about it. It is not just a monotonous test. (Observation of Rowan using multimedia program)

The following excerpt is also a good example of a thoughtful evaluation of a child's answer to an open-ended question and her method of producing a variety of correct answers in a systematic way:

It's the solution. Look what she's done. She's thought about that hasn't she? Smart little girl ... She found the first one, and then she says 'Well if I take one off that and add one to that, it has to give me the same answer', and just kept doing it. (Observation of Rowan using multimedia program)

Multiple perspectives

A statement or question was classified in this category if it suggested an alternative approach or challenged a conclusion, or previously made point, by providing an alternative perspective (Table 8.18). Such challenges need not be argumentative or vigorous. Multiple perspectives were given in response to disagreements with both the partner in the group and with ideas presented in the assessment program itself.

Table 8.18:   Instances of talk categorised as Multiple perspectives

	Group 1: Debra & Glen	Group 2: Evie & Louise	Group 3: Rowan & Carlo	Group 4: Zoe & David
Number of units of meaning	11	2	55	42
Percentage	6%	1%	17%	18%

The following excerpt is a typical example of the manner in which the students provided alternative points of view in their disagreements with each other. In this example, Zoe insisted that there are few benefits to the use of pencil and paper tests, a view challenged by her partner:

David: [Play *Pencil and paper*, teacher] Did you get that? It's easy to score.

Zoe: That's terrible.

David: That's the only benefit.

Zoe: That's not a benefit.

David: It's the only thing worthwhile about them.

Zoe: But it's still not a benefit.

David: Well it's the only good thing about it, let's put it that way ...

Zoe: It does not ... It's easy for the lazy teachers, that's what it is.
(Observation of David and Zoe using multimedia program)

This type of vocal disagreement occurred frequently with this particular group. More thoughtful and productive disagreements occurred in other groups, such as in the following example, where one student challenged another's equation of factual recall with rote learning:

Rowan: OK investigations, factual ... Ah, factual, factual recall, rote learning.

Carlo: No, it's not saying you learn everything by rote, it's just saying that sometimes you want students to respond automatically. It's something they should know without having to think. (Observation of Rowan and Carlo using multimedia program)

In this instance, Carlo provided a very useful distinction between the two concepts and helps to further the group's investigation of the assessment strategies. Similarly, in the following example, one student was challenged to explain how self-assessment could be used in mathematics assessment. Debra's answer gave an alternative perspective on the value of self-assessment in the area of mathematics, a form of assessment which has traditionally been associated with the social sciences:

Debra: Now self-assessment. I'd say in general it works pretty good.

Glen: In maths?

Debra: Yes. Not just having a maths journal, having a journal for all subjects and having a time like at silent reading where all the kids write in their journal about what they've done during the day and how they thought about it. It's not marked but kids can say how they went … and they can be honest about it. (Observation of Debra and Glen using multimedia program)

The student explained how a journal can be used across all subjects by school students to encourage them to reflect on their learning, and in so doing provided a non-stereotyped perspective of the use of writing in mathematics.

As well as challenging each other as they worked together on the program, students in the groups also disagreed with ideas and concepts presented in the program itself. For example, in the following excerpt, one student took issue with a teacher's statement on one of the video clips about remediation:

What do you think when you hear remediation? Because she said if all the class had done poorly they obvious need remediation. But if all the class had done poorly then the teacher obviously needs to reassess the teaching … You can't put it back on the students! It is not the students' fault if all of them haven't understood it … This is a problem I have with teachers, they have only got time for the top students and everyone else needs remediation. (Observation of Rowan using multimedia program)

Others simply expressed anger or frustration at views which they clearly thought were unsustainable, such as in the following example:

Zoe: … This is making me angry … [it's] stupid to say that a teacher can work with each student on a one to one basis. Is that correct or not?

David: Well unless there are less students. (Observation of Zoe and David using multimedia program)

The majority of alternative perspectives were provided against either the student's partner or against the issues provided in the program, as described above. However, one student also brought in multiple perspectives in his disagreements with the education system as a whole, or more specifically with his own experiences within the education system:

> Well, I am especially against the fact that if someone passes they should pass, you can't grade them so that they fail. That's wrong ... I repeated Year 12 English because of that, because I failed it the first time. Well I got ... a pass mark to get to uni and they scaled me down to 46.4 ... I passed the unit and then they say 'That's not good enough, you have failed'. (Observation of Rowan using multimedia program)

All the groups had a good representation of this type of talk with the exception of Group 2. This group again seemed to be hampered by the fact that the two students barely knew each other when they began working on the assessment program together, and they seemed reluctant to openly disagree with each other or to strongly put an alternative point of view.

Imposing meaning

Talk was classified into this category if it referred to a possible solution or a decision about what to believe, if it drew cautious conclusions, or if it expressed the creation of a new idea (Table 8.19). Such talk was generally observed when students were drawing conclusions about each section of their report, and discussing what their recommendations were going to be when they gave their report at the 'staff meeting'.

Table 8.19:   Instances of talk categorised as Imposing meaning

	Group 1: Debra & Glen	Group 2: Evie & Louise	Group 3: Rowan & Carlo	Group 4: Zoe & David
Number of units of meaning	23	5	26	9
Percentage	13%	2%	8%	4%

When the students engaged in looking at the findings of their investigation into the assessment strategies and putting them into the form of recommendations to the staff, there were several examples of talk which fitted into this category of *Imposing meaning*. For example, the following two comments were both on the subject of checklists as an assessment strategy. Both attempted to impose some meaning on the best use of

checklists with students. The first student suggested that the use of checklists needs to be carefully planned for optimum effect:

> Checklists. You would have to do it frequently so you could see if there was any patterns or any relationships. Like you would do it when you have got them working really hard ... you wouldn't do it maybe in the first couple of lessons. (Observation of Evie using multimedia program)

The second student compared checklists to diagnostic testing as a simple but effective check on the level of students' confidence in using mathematical skills:

> See, testing is really good for diagnostic because you can identify areas of difficulty and suggest challenging tasks that help them confront their problems. But even with checklists, if you make up a good checklist of the skills you expect them to learn, you can identify the particular skills straight away ... But it's going to test how confident they are with that skill, not whether they know it or not. (Observation of Rowan using multimedia program)

Comments which fitted into the category of *Imposing Meaning* were not always isolated comments. In several instances, a particular student developed a train of thought or idea as he or she used the program. For example, in the following excerpt, Glen expressed his idea about the appropriateness of using particular types of assessment strategy at different levels of the school:

> They probably don't need to be formally assessed. Obviously we can introduce all of the strategies but not to start with. I think in the lower primary you probably can't expect them to do a mathematical investigation, so if they start out with oral work in the lower school and work towards doing the written ones in the upper school. And that probably ties in with that doesn't it?

Glen continued with this idea and it began to develop as an organisational framework for the school policy he and his partner would recommend to the staff:

> Again, I'd suggest that to start off in the lower primary school with the question there for them, and lead in to getting them to develop their own questions.

Towards the end of the observation, Glen again demonstrated his wish to impose a structure on the material he had investigated by suggesting that age level is not the only relevant criterion for the order of introduction of assessment strategies. He suggested that ease of implementation might be an important consideration for the school:

> I think if you're introducing it as a school policy, then I'd tend to think that the structured is more easy to implement than the open to start with. (Observation of Glen using multimedia program)

The interrelating of conceptual elements was also classified in the category of *Imposing meaning*. In this example, Debra demonstrated an understanding that two different assessment strategies may be used for the same purpose:

> They're both the same in a way [Structured and Open]. Like they're both encouraging the kids to clarify their ... they have to explain themselves. So they have to think about what things are about and in a way clarifying it in their own minds. (Observation of Debra using multimedia program)

Instances of talk which fitted into the category of *Imposing meaning* were less common that other types of higher-order learning such as *Judgement*, and they generally occurred at times when the students were summarising their understanding of the assessment strategies in preparation for their report to be given at the staff meeting.

Metacognition

Frequencies of talk classified as *Metacognition* are provided for each group in Table 8.20 below.

Table 8.20:   Instances of talk categorised as Metacognition

	Group 1: Debra & Glen	Group 2: Evie & Louise	Group 3: Rowan & Carlo	Group 4: Zoe & David
Number of units of meaning	11	9	9	5
Percentage	6%	6%	3%	2%

Flavell (1976) gives some very concrete examples of metacognition in action:

> I am engaging in metacognition ... if I notice that I am having more trouble learning A than B; if it strikes me that I should double-check C before accepting it as fact; if it occurs to me that I had better scrutinize each and every alternative in a multiple-choice type task situation before deciding which is the best one; if I become aware that I am not sure what the experimenter really wants me to do; if I sense that I had better take note of D because I may forget it; if I think to ask someone about E to see if I have it right. (p. 232)

Talk classified in this category included both comments which showed that students were aware of their own thinking and performance, and comments related to the use of this awareness to improve performance (Vockell & van Deusen, 1989; Garofalo & Lester, 1985). Students using the assessment program exhibited instances of both types

of metacognition. For example, the following unrelated excerpts show evidence of the students' awareness of their thinking or performance as they used the program:

I don't know. I don't know where I am. We got caught in a traffic jam.

I've no idea. How about you suggest something and I'll evaluate it.

What was that? I didn't get any of that.

I've got a blank.

So where were we up to? Oh, we've got so much to do.

These are all examples of students' spontaneous admission that they are unsure or don't know how to respond in certain instances. The following examples show situations where the students use that awareness of their thinking to act. The first excerpt shows an awareness that the students are not sure of the requirements of the task and the action is for one of them to approach the teacher for advice:

We should, shouldn't we. So am I actually typing out what we're going to say? Or is it a report to give to the staff? Put your hand up and ask. (Observation of Debra using multimedia program)

In the following instance, one of the students showed an awareness that he needed further information on the Higher-order strategy to envisage how it would work. The action he took is to look in the Samples drawer of the filing cabinet to examine the diagram:

I want to see the diagram, I don't think it would work with that much information. [Looks in Samples drawer]. (Observation of Glen using multimedia program)

Other simple examples include awareness that a student may have missed the point of one of the scenarios and the action was to view the video clip again, or admission that a student didn't know what to do and consulted with the original task sheet of memos.

One interesting use of metacognition demonstrated in one of the groups on more than one occasion was an awareness of postponement of thinking. This was done in relation to the notebook, which appeared to be seen by several of the students as a storehouse to be used at a later date (a limitation of multimedia notebooks discussed by Harper, Hedberg, Wright, & Corderoy, 1995). For example, in the following discussion, one student challenged the other as to why he has put so much in the notebook. The other student's reply revealed that his metacognitive strategy was to cut and paste now, think later:

Rowan: Why'd you do that?

Carlo: Rather than think too much we'll just cut and paste ... We'll think later. (Observation of Rowan and Carlo using multimedia program)

Students revealed several instances of metacognitive strategies in their discussion as they completed their reports using the interactive multimedia program on assessment, although with all groups it did not constitute a substantial proportion of their talk.

Discussion

This part of the thesis has attempted to answer the third research question: *What types of higher-order thinking do students employ while using an interactive multimedia program based on principles of situated learning?*

The analysis of the transcripts of students' talk according to a variation of Resnick's (1987a) characterisation of higher-order thinking, showed that higher-order thinking was a substantial component in all the students' talk. Figures 8.2–8.5 show the proportion of higher-order thinking to the other major categories observed: *Social, Procedural* and *Lower order*, for each of the groups observed.
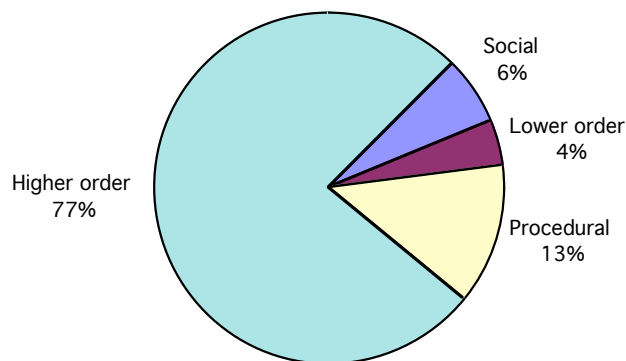
Figure 8.2:   Proportion of categories of talk: Debra and Glen

The two students in the pilot group used a substantial proportion of higher-order thinking in their talk as they used the interactive multimedia program on assessment. Lower order comments, together with social talk, were kept to a minimum and procedural matters occupied only a moderate amount of their time.
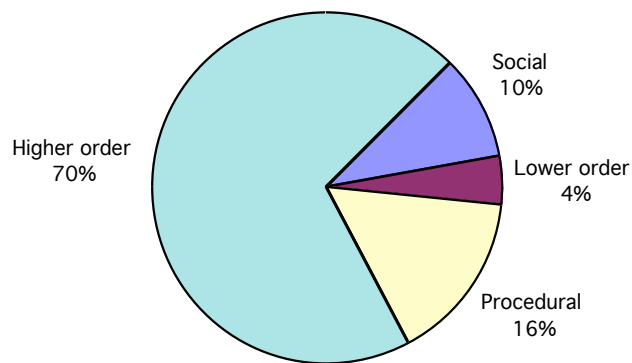
Figure 8.3:   Proportion of categories of talk: Rowan and Carlo

Like Debra and Glen, Rowan and Carlo used a substantial proportion of higher-order talk, a moderate amount of procedural and minimal lower order talk. Of all the groups, this group had the most social talk, largely centred around discussion of their mutual friends, computers and work from other units of study.
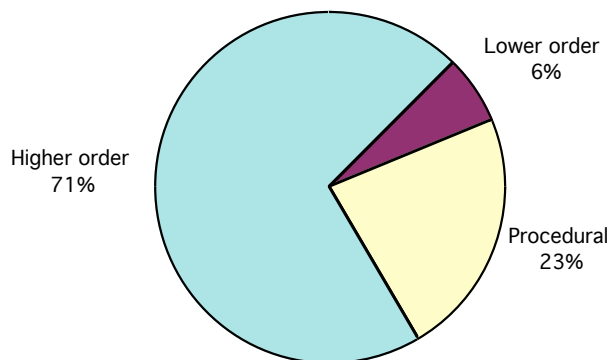
Figure 8.4:   Proportion of categories of talk: Louise and Evie

Louise and Evie were least typical in their pattern of talk as they used the interactive multimedia program on assessment. The complete absence of social talk appeared to be the result of the fact that they did not know each other prior to commencing work on the program. The relatively high amount of procedural talk observed in this group was largely related to recurring computer equipment problems which were not satisfactorily rectified until the second week of the study. Like the other groups, however, they had a high proportion of higher-order talk, and minimal use of lower order talk.
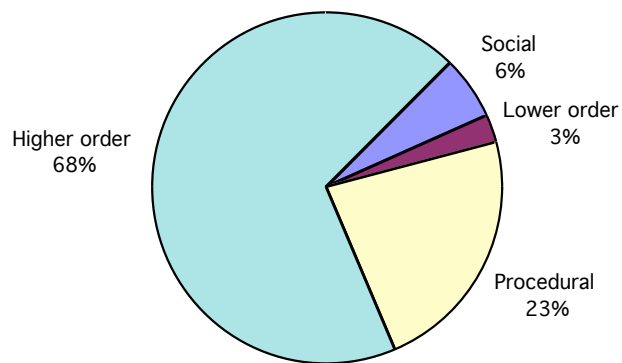
Figure 8.5:   Proportion of categories of talk: Zoe and David

Zoe and David were similar to the other groups in their use of a substantial amount of higher-order talk. The remaining categories were also comparable with other groups.

The high level of higher-order thinking amongst all the groups meant that there was a substantial number of units of meaning in students' talk which could be classified according to the classification scheme described earlier. Each unit of meaning was categorised as *Uncertainty, Path of action, Judgement, Multiple perspectives, Imposing meaning* or *Metacognition*. The proportion of each of these types to the whole of higher-order talk (not *all* talk) for each group is given below in Figures 8.6–8.9.
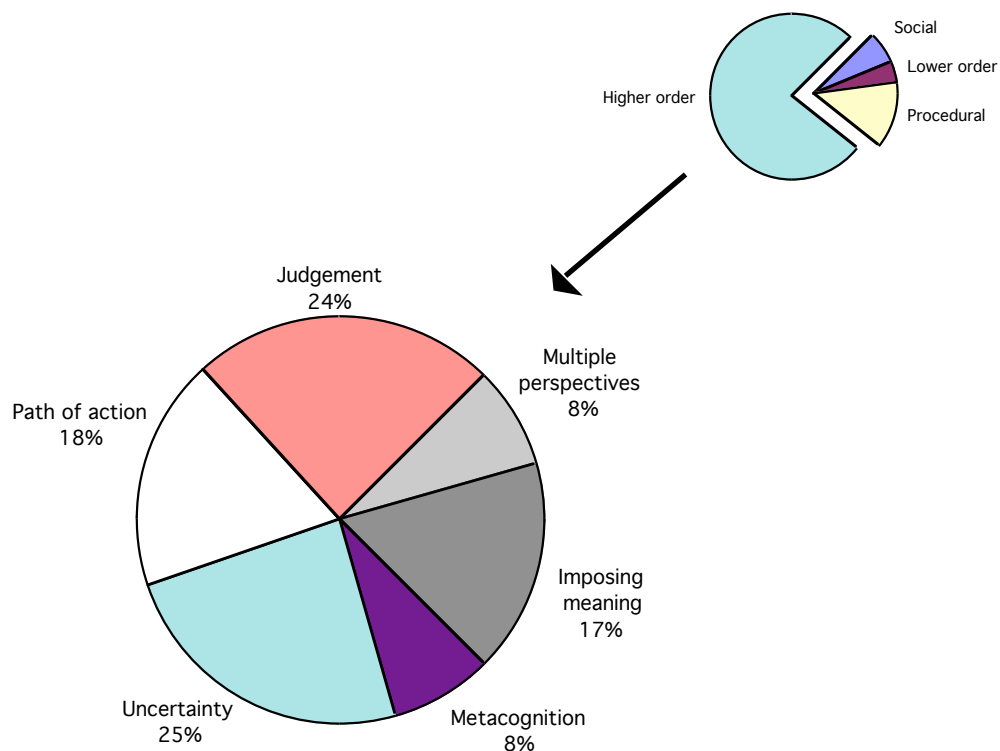
Figure 8.6:   Proportion of categories of higher-order thinking: Debra and Glen

Debra and Glen used a substantial amount of all types of higher talk identified in the classification scheme (Figure 8.6). As with most of the groups, *Uncertainty*, *Path of action* and *Judgement* comprised the major part of their talk, with the other classifications making up the remainder.

One would expect that comments related to *Uncertainty* and *Path of action* would take up a reasonable portion of students' time in collaborative groups as they would use this type of talk to decide where they would go within the program and how they would approach the task. It might be expected that students who did not know each other well would have a larger amount of this type of talk as they negotiated the group dynamics and established a working relationship. Clearly, Debra and Glen were relatively comfortable working together, with the total of these two types of two totalling less than half their talk.

The moderate proportion of *Multiple perspectives* appears to indicate that these students were not excessively argumentative or critical, but were not afraid to challenge each other or the program when they saw the need. These students were also capable of spending a good proportion of their time *Imposing meaning* on their learning and coming to conclusions about the task and the recommendations to include in their

reports. As with all the groups, these students' expression of metacognitive awareness was minimal, and it is possible that this is a type of thinking which does not manifest in the spoken word as well as the other categories of talk.
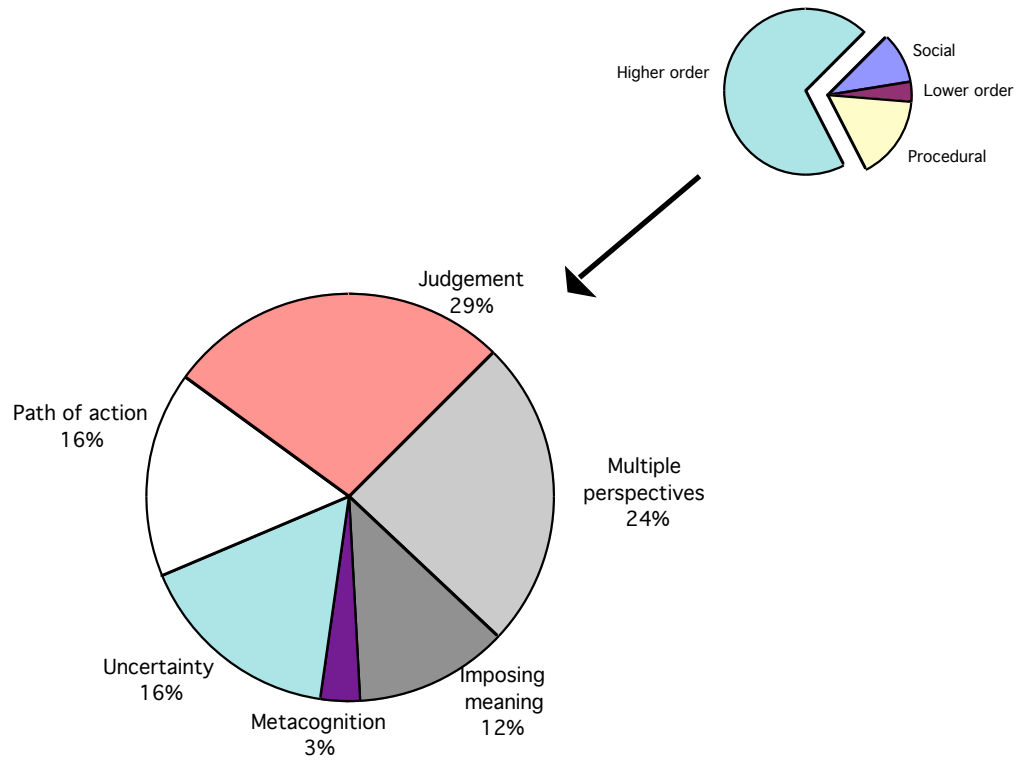
Figure 8.7:   Proportion of categories of higher-order thinking: Rowan and Carlo

The interesting aspect of the analysis of Carlo and Rowan's talk(Figure 8.7) is the relatively low proportion of *Uncertainty* and *Path of action* compared to *Judgement* and *Multiple perspectives*. This division indicates that these students were forthright and confident in working out their path through the interactive multimedia program, and that they appeared to very comfortable working together.

The high proportion of *Multiple perspectives* indicates that they adopted a very critical approach to the information they were obtaining from the program and from each other. The high proportion of *Imposing meaning* also seems to indicate that they were then readily able to consolidate the information into a meaningful form. Like Glen and Debra, Carlo and Rowan expressed little *Metacognition* as they worked together on the interactive multimedia program.
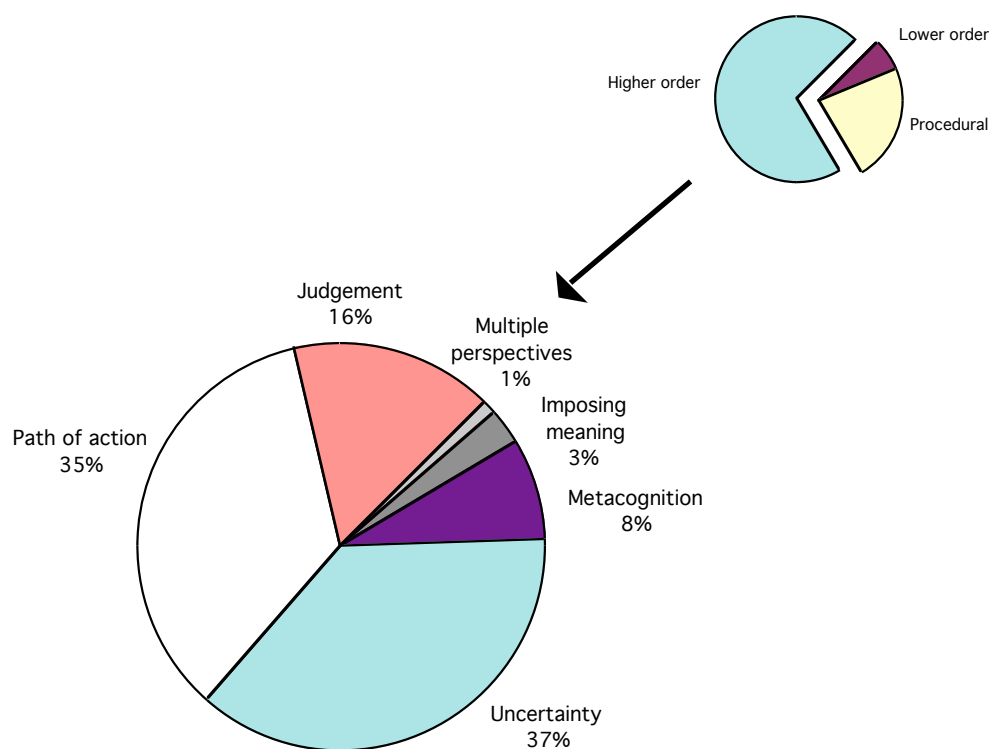
Figure 8.8:   Proportion of categories of higher-order thinking: Louise and Evie

While it is difficult to nominate an optimum spread of talk to categories within higher-order thinking, clearly this group had difficulties which become apparent with closer scrutiny of their types of talk. The high percentage of time spent by Louise and Evie (Figure 8.8) in both *Path of action* and *Uncertainty* reflects the tentative nature of their collaboration. Almost three quarters of the total talk fell into one or other of these categories. As they were unaccustomed to working together, they appeared to spend a relatively large proportion of their time consulting with each other about the nature of their collaboration—how they were to proceed, how to interact, and the responsibility each was to take in the process. The remaining groups were not hampered by these concerns, possibly because they had all worked with their partner on several previous occasions.

Another interesting finding in the proportion of talk for this group was the almost complete absence of *Multiple perspectives* talk between the two students. Their collaboration was characterised by a reluctance to challenge each other's ideas or to challenge the perspectives that were presented in the multimedia program. The very low proportion of *Imposing meaning* was also indicative of a failure to confidently adopt a position to present in their final report.
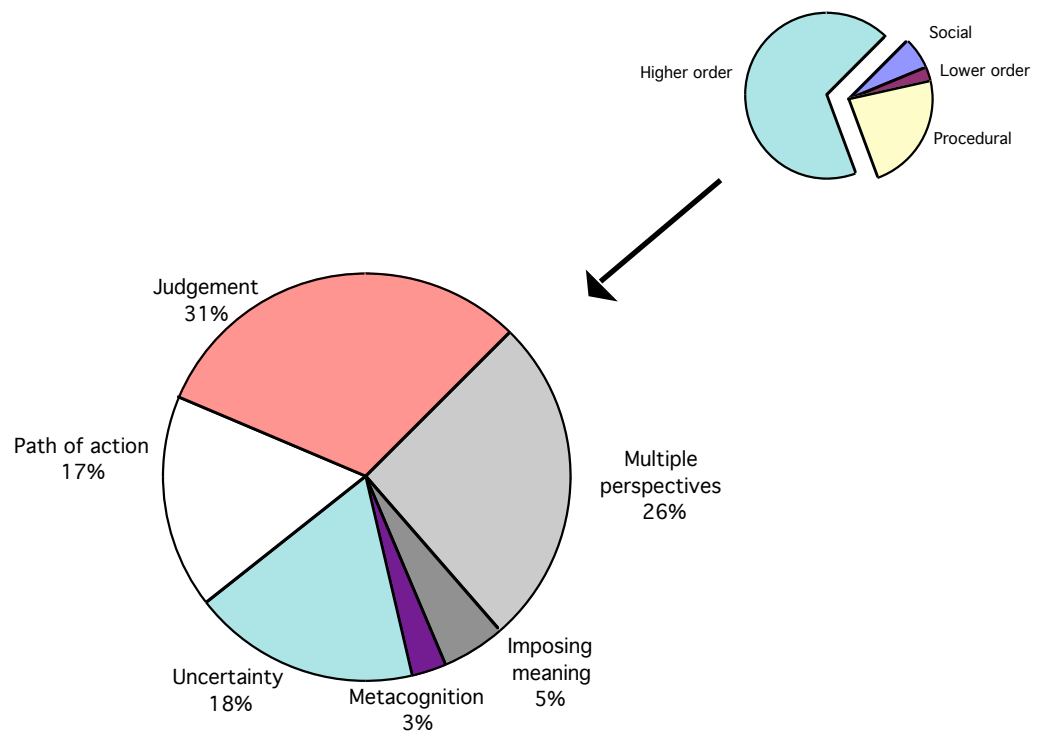
Figure 8.9:   Proportion of categories of higher-order thinking: Zoe and David

Zoe and David used relatively little talk which was classified as *Uncertainty* and *Path of action* indicating that they needed minimal talk to establish a working relationship and a proposed plan of action. These students also used a high proportion of judgement in their talk, indicating that they felt at ease sharing such observations with each other, and were not tentative in their discussion. Like Rowan and Carlo, Zoe and David used a high proportion of *Multiple perspectives* as they used the multimedia program. However, a large proportion of this was an argumentative style of interaction they used as they worked together, rather than a thoughtful disagreement with ideas presented in the program. This is possibly evident in the fact that there was a minimal proportion of talk which was classified in the category of *Imposing meaning*. These students, unlike Rowan and Carlo, did not use the multiple perspectives they offered each other to inform the meaning of the task.

It is interesting to note the wide disparity between types of higher-order thinking used by the students as they used the interactive multimedia program on assessment. The findings show that all the students used a substantial proportion of higher-order thinking in the situated learning environment, where other studies (e.g., Frampton,

1994; Oliver & McLoughlin, 1997) have shown little. The possibility exists that the classification scheme developed to analyse students' talk was not a precise enough instrument to truly reflect the cognition of students as they used the program. This issue has been raised by Frampton (1994) who suggests that many of the classification schemes he reviewed were unsuitable for the analysis of 'technology-supported cognitions' (p. 90). He stated that: 'It is not clear, in our view, that current means of identifying cognitive events can adequately cater for responses to the organisation of media in a multimedia program' (p. 90).

While the current classification scheme was specifically developed for use with multimedia, its interpretation of higher-order thinking may be too liberal. For example, many of the comments and statements classified as *Uncertainty* and *Path of action* may actually be better defined as *Lower order* thinking, simply because such comments may require little mental effort. For example, comments such as 'What do you want to do now?' may be closer to a cliché or automatic response than a thoughtful reflection of the best course of action. While many of the theorists and researchers would argue with this view (e.g., Ennis, 1993; Duchastel, 1990; Lewis & Smith, 1993), it is interesting to reclassify the data accordingly. For example, Figure 8.10 shows the proportion of higher-order thinking, when all the incidences of *Uncertainty* and *Path of action* for one of the groups of students have been reclassified as *Lower order*.
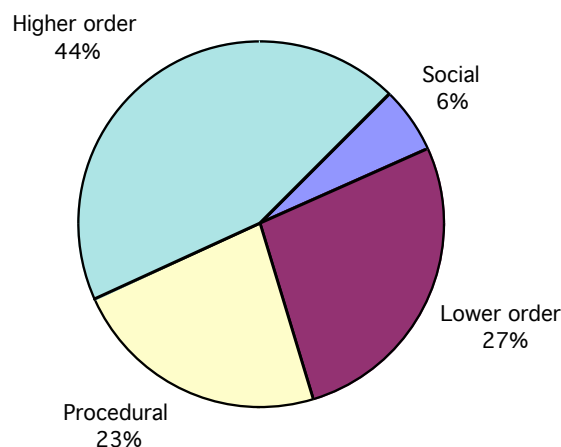
Figure 8.10:   Proportion of categories of thinking when all Uncertainty and Path of action are classified as Lower order: Zoe and David

The pie chart shows that, even with this recount, *Higher-order thinking* remains a high proportion of the type of talk used by this group, and this was so for all the groups. Perhaps a more plausible explanation for the high level of this type of talk is that the constructivist nature of the learning environment provided greater opportunities for

students to engage in higher-order thinking, a finding also confirmed by Maor and Taylor (1995).

Another interesting finding was the non-sequential nature of the types of thinking used by the students, confirming Resnick's (1987a) and Newmann's (1990) contentions that higher-order thinking is relative and non-hierarchical, and counter to behavioural theorists such as Bloom (1956) and to some extent, Gagné (1985), where progression to each level of the hierarchy is dependent upon mastery of the previous level.

If one accepted a hierarchical approach to classification of thinking, it might be expected that students would begin with a little social talk to establish their working relationship; then procedural talk as they worked out the computer equipment, the software and the task; they might then be expected to move to lower order talk before using higher-order talk later in the session. Interestingly, there was no sequence or pattern to their use of talk. From the beginning, they moved freely and without notice to any type of talk. For example, Figure 8.11 gives a chronological representation of the first 50 instances of units of meaning used by one group of students.
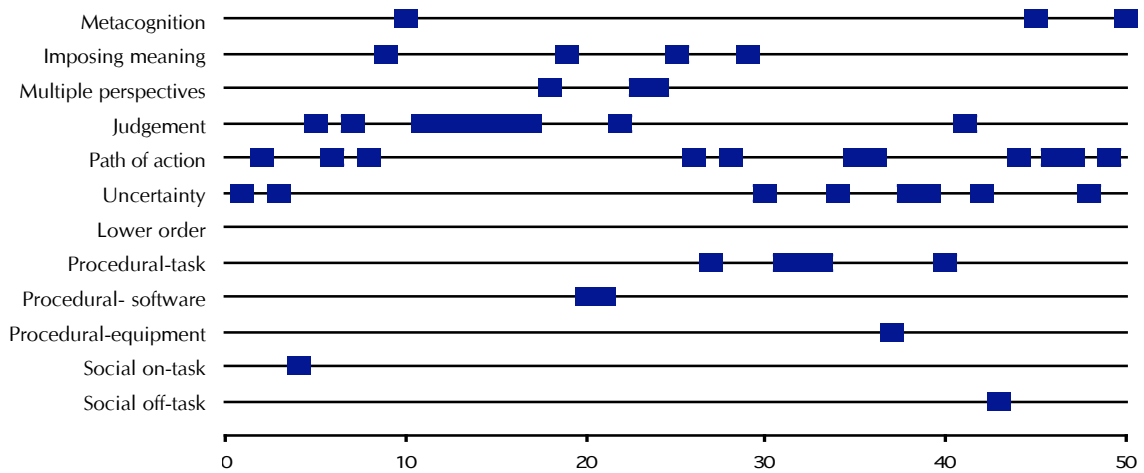
Figure 8.11:   Chronological order of sample of 50 types of talk: Debra and Glen

The graph clearly shows the non-sequential nature of the types of thinking used, and the absence of patterns. The same was true for the remaining groups.

Summary

The analysis of types of talk used by students as they worked with the assessment program clearly shows that the majority of their thinking was higher order, as defined by Resnick (1987a) and other theorists. Social, procedural and lower-order talk was less evident but present in their talk in reduced proportions.

One limitation experienced with the classification scheme and its use with transcripts involved the necessary interpretation of meaning without any contextual factors to assist. For example, the simple phrase 'I don't know' could be interpreted as *Metacognition, Uncertainty* or *Lower order*, depending upon the context and the way it was said. There is a great deal of personal judgement which must be brought to bear on such interpretation, and which may affect the validity of such a classification scheme. The scheme used here worked well for a single researcher, but greater refinement would be required for more widespread use. The *VideoSearch* software (Knibb, 1997, currently being developed) for analysis of qualitative data in video form shows a great deal of promise for providing many more contextual cues for analysis than a written transcript, and with further development would ameliorate many of the current problems researchers face in this regard. (The software was not used for analysis of this part of the research because it was not capable, at the time, of dealing with the large video files required.)

Two findings were particularly interesting in their implications for further research. One group, whose students who did not know each other before their collaborative use of the assessment program, appeared to use different types and proportions of thinking to the groups who had worked together before. The finding suggests that social ease and experience at collaboration facilitates higher-order thinking. Further research is needed to establish the relevant determinants for this finding and the implications for classroom practice.

The second interesting finding was the high proportion of argument and challenge found in two of the groups observed. As described earlier, one group appeared to use this process to enlighten the meaning they constructed, the other group did not. Again, further research is needed to ascertain whether a pattern can be deduced in this regard, and to determine the factors which lead to the construction of meaning from multiple perspectives.

While it was not within the scope of this study to examine whether a causal relationship exists between the use of higher-order thinking and students' use of assessment strategies in the classroom, clearly this is another opportunity for valuable

research. Higher-order thinking, and other factors such as beliefs and attitudes, and their translation into practice is an area worthy of greater investigation.

Transfer analysis and discussion

One of the principal claims of the proponents of situated learning is that it facilitates transfer of knowledge to novel situations. In the present study, transfer was thought to have occurred if firstly, students using the interactive multimedia program on assessment had a good understanding of the types of assessment appropriate in the mathematics classroom and were able to articulate this understanding; and secondly, they employed a variety of the assessment techniques shown in the program, as opposed to the predominant use of pencil-and-paper tests. These criteria, based on the work of the Cognition and Technology Group at Vanderbilt (1993a) were described more fully in Chapter 2.

This chapter provides analysis and discussion of Part E of the research: the transfer study. It reviews the methodology used to collect the data, and then reviews the types of assessment strategy used by each of the students in the study on their professional practice. The chapter then provides some discussion of issues and themes which emerged from analyses of the data.

Research question 4:

How effective is an interactive multimedia program based on principles of situated learning in promoting transfer of knowledge to classroom practice?

Framework and method of analysis

In order to answer the research question, data was gathered from interviews with the students' supervising teachers after their two week professional practice in schools, and three part interviews with the students themselves. Techniques of qualitative analysis recommended by Miles and Huberman (1994), Eisner (1991) and McCracken (1988) were used to analyse the data as for the other studies, and as described in Chapter 6.

Assessment strategies used by students on professional practice

Approximately 5 weeks after the conclusion of the use of the assessment multimedia package in their mathematics method course, the six students in the main study completed a two week professional practice in six different schools in the metropolitan area (the transfer study was not conducted with the pilot study students). All the students were required to teach mathematics classes in this practice, and it was expected that they would have the opportunity to implement different assessment strategies at this time. In order to assess whether students used a variety of assessment strategies during their mathematics classes on professional practice, both the students and their supervising teachers in the schools were interviewed and the comments were analysed. The professional practice experience of each student, with regard to assessment strategies in mathematics, is summarised below.

Evie

Evie's professional practice was conducted in a co-educational, non-government secondary college where she taught Years 8, 9 and 11 mathematics. During the two week practice, she was supervised by Carol at all levels. The use of the different categories of assessment strategies used by Evie, as defined in the interactive multimedia program, is presented below in Table 9.1. It shows both Evie's, and her supervising teacher's, reports of the types of assessment used under the headings of the major categories of assessment strategies shown on the main interface of the assessment program.

Table 9.1:   Assessment strategies used by Evie during professional practice

Source	Assessment strategies					
	Observing	Questioning	Interviewing	Testing	Reporting	Self-assessment
Evie	Anecdotal records	Mainly higher-order	Open and structured interviewing	Pencil-and-paper problem solving activity (formal requirement)	None	None
Supervising teacher: Carol	Wrote notes on individual students	Mainly factual recall	Open interviewing	Pencil-and-paper problem solving activity (formal requirement)	None	None

The main form of observation, as an assessment strategy, used by Evie was anecdotal records. She used this strategy during mathematics classes by taking notes on individual students as she moved around the classroom:

> I observed with anecdotal, so I did take a note down of people who did seem to have problems with things, and I jotted down what they were, so I could actually go back and help them at any time or in their free time or whatever. (Interview with Evie)

This use of anecdotal records was acknowledged by her supervising teacher who also noted that some of the records appeared in annotated form as part of Evie's self-assessment of her own teaching. Evie's use of anecdotal records was something she initiated without the suggestion being made by her supervising teacher.

Carol felt that Evie's questioning technique comprised mainly factual recall rather than open-ended or higher-order questioning. However, she did acknowledge that Evie used questioning both with groups and individually, and that 'she was able to do the question and answer thing quite well' (Interview with Carol). Evie herself said that she felt quite confident with questioning and used it frequently, particularly higher-order questioning. Again, questioning was used on her own initiative, especially with individuals, as she moved around the classroom. While acknowledging that some kinds of interviews were not feasible during professional practice, such as parent interviews, Evie felt that she had used open-ended and structured interviewing extensively:

> I did a lot of interviewing, I'd actually walk around and ask them if they were having any problems and if they were, then why, and what did they find difficult, and just questions like that. (Interview with Evie)

The supervising teacher corroborated this comment and also pointed out that this strategy was used on Evie's own initiative. Evie did not use any paper-and-pencil tests that she herself had designed, but was required to administer a problem-solving test. Neither Evie nor the supervising teacher initiated the formal test:

> Neither of us [initiated the test]. It was a requirement, a policy of our school and it just happened, like we'd set dates from the beginning of the year and that was the day that it was going to be administered, so she did that. (Interview with Carol)

Evie did not use any self-assessment strategies such as journal writing or reflective prompts, and no reporting strategies such as oral, written, portfolios or modelling. Her justification for this was that such strategies needed to be an ongoing part of the learning environment, rather than something that could be quickly introduced in a short professional practice period:

> I was limited in what I could do. If you're doing something like a portfolio, you need to start at the beginning of the year and progress. If the teacher hasn't done that from the beginning of the year, it's not worth doing in two weeks. (Interview with Evie)

Generally, Evie used a variety of assessment strategies, and was proactive in initiating the use of alternative strategies that were under her control, such as the strategies that could be used with individual students as she monitored students' work.

Louise

Louise was assigned to a single sex, non-government secondary college for her professional practice. She taught Year 9 mathematics, and was supervised by Michael. As a double major, she shared her teaching practice between two subject areas: language and mathematics. Because of this, she taught only two classes with her assigned supervising teacher of mathematics. Louise's view of the assessment strategies she used is summarised in Table 9.2, together with the views of her supervising teacher.

Table 9.2:   Assessment strategies used by Louise during professional practice

Source	Assessment strategies					
	Observing	Questioning	Interviewing	Testing	Reporting	Self-assessment
Louise	None	Higher order and factual recall	Open interviewing	Informal pencil-and-paper tests	Individual students reporting orally to the class	None
Supervising teacher: Michael	None	Factual recall	Open interviewing	Informal pencil-and-paper tests	Individual students reporting orally to the class	None

Louise did not use any formal method of recording the observations she made of students, such as recording anecdotes or the use of checklists. However, she did use higher order and factual questioning:

> I used a lot of questioning when introducing similar triangles to find out what they knew, and increasing it, trying to let them work out how to do it first rather than me just explaining it to them. And the factual questioning, I probably used for mental. (Interview with Louise)

Her supervising teacher stated that Louise had used mainly factual recall questioning, but did agree that she used questions in a class discussion on her own initiative. Both Louise and Michael agreed that she used open interviews with individual students to help diagnose possible problems with understanding. Paper-and-pencil tests were also used by Louise, but they were used informally in a manner designed to gauge understanding rather than the 'right' answer. Her supervising teacher explained the method she used:

> It was informal. She didn't actually collect it, she assessed it from the point of view of walking around the class ... querying students question by question and just getting general feedback on whether there were any problems with a section of the work. (Interview with Michael)

Louise used reporting as a strategy by asking students to present their findings and solutions orally to the class. Her supervising teacher pointed out that for both testing and reporting, Louise used techniques she had seen demonstrated by him the previous day. All the other assessment strategies were done on Louise's own initiative. Self-assessment strategies were not used by Louise in her professional practice classes. She

pointed out the difficulties of using strategies such as journals and peer assessment in what was effectively, another teacher's class:

> I would use them more if I had my own class, but being in someone else's class, it's harder to incorporate things like that. (Interview with Louise)

Louise's comments echo those of Evie in her concern for the difficulties associated with implementing procedures and techniques in a short space of time on professional practice. Nevertheless, there is evidence to show that at times when it was within her control, she did utilise many alternative assessment strategies.

Rowan

Rowan completed his professional practice in a co-educational, government high school catering for Years 8-12. Under the supervision of Rob, Rowan taught Years 8, 9 , 10 and 11 mathematics. Rowan's and Rob's reports of the assessment strategies used during the professional practice are presented in Table 9.3.

Table 9.3:   Assessment strategies used by Rowan during professional practice

| Source | Assessment strategies | | | | | |
	Observing	Questioning	Interviewing	Testing	Reporting	Self-assessment
Rowan	Anecdotal records and checklists	Factual questioning	Open interviewing	Two formal tests	None	Reminders to students as reflective prompts
Supervising teacher: Rob	None	Factual questioning	Open interviewing	Pencil and paper test of parabola	None	None

While Rowan's supervising teacher was not aware of any observation of students, Rowan himself reported that he tried to use both types of observing presented in the interactive multimedia program on assessment, particularly anecdotal records:

> I was trying to do both of these actually, not fully into the checklists, but observing and ... writing down some little notes about how certain ones were doing, even for the next lesson, so I'd note that they were having a problem. You can see that a lot of teachers would ignore them and the fact that they were having a problem and then in the last lesson say 'You haven't been listening, you haven't been doing the work', whereas if you've got those little notes there you can see that they've been having a

problem and you can keep concentrating on that particular area. So I was trying to use those two. (Interview with Rowan)

Rowan admitted to having a problem with group questioning, pointing out that he found it difficult not to use rhetorical questions, a point also made by his supervising teacher. Nevertheless, he showed that he was willing to use the strategies and try to perfect his techniques:

Towards the end, in certain classes I was asking the How and Why questions. To actually find out where they're at, I prefer to use individual questions, you know, going around ... then I'll tend to use like all three types of questioning techniques. (Interview with Rowan)

Both his supervising teacher and Rowan concurred that he used open interviewing to help students who were having difficulty understanding mathematical concepts, and that this assistance was provided on Rowan's own initiative. Rowan used two pencil-and-paper tests during his professional practice. The tests were administered in a formal manner, as explained by the supervising teacher:

[He] stood at the front of the room explaining that it was a test, what they were to have on their desk, pens, pencil and calculator, gave out the test, ensured everyone knew it was 2 pages, right you've got 40 minutes, look at the clock, get to work. (Interview with Rob)

Rowan explained, however, that he used the results as the basis of a discussion on students' understanding of the problem. This procedure was demonstrated in the scenario on pencil-and-paper testing on the interactive multimedia program. Rowan's comment reveals an insight which suggests his use of the tests was to gain a true assessment of students' understanding rather than to obtain a score:

The teacher wanted me to keep the tests for my own record, but the last day was a sports test and only 10 [students] were there, so I—this was interviewing as well—I went through the test and discussed things and clarified things where they'd got it wrong and to see whether they actually did know it. A lot of the time in a test they get it wrong but they still might understand the concept. That's all part of assessment, not just whether they got it right on the day. (Interview with Rowan)

Rowan did not use any reporting strategies to assess students' understanding during his teaching practice, nor did he use any self-assessment techniques other than encouraging students to assess their own understanding at regular intervals.

Rowan appeared to use a variety of assessment strategies in his mathematics classes during professional practice in a school. Like Evie and Louise, he was limited in the

scope of the strategies he could use by the time constraints of the placement. Rowan's comments reveal a far deeper understanding and application of assessment strategies than was evident to his supervising teacher.

Carlo

Carlo's professional practice school was at a co-educational government high school, catering for Years 8 to 10. The school had four timetabled periods per day, and Carlo taught 8 periods of Years 8, 9 and 10 mathematics during the two week practice under the supervision of Peter. During his teaching practice, Carlo reported using a number of different assessment strategies. These are summarised, together with the views of his supervising teacher, in Table 9.4 below.

Table 9.4:   Assessment strategies used by Carlo during professional practice

Source	Assessment strategies					
	Observing	Questioning	Interviewing	Testing	Reporting	Self-assessment
Carlo	Informal observation	Open-ended questioning	Open interviewing	Mental tests to start every Year 8 lesson	Observed modelling	Informal reflective prompts
Supervising teacher: Peter	None	Factual recall questions	Open interviewing	None	None	None

Both Carlo and his supervising teacher agreed that no observation techniques were used by Carlo to assess students in his practice classes, although he did explain that he observed their progress without writing notes: 'It was just seeing' (Interview with Carlo). While his supervising teacher claimed that Carlo used only factual recall questioning with students, Carlo himself related a different view:

> I used open-ended questions, because I had to introduce means and standard deviations, so there were quite a few ideas around that. You could use them in investigation type activities, because I've done that with a couple of Year 10s ... That's just the nature of the activity. There are so many different ways of doing it. (Interview with Carlo)

The supervising teacher reported that Carlo did not use open-ended questions:

> They were factual recall. He knew what answer he wanted and students responded accordingly. (Interview with Peter)

Nevertheless, when asked whether he had suggested the idea to use this type of questioning or whether it was Carlo's, the teacher replied that his role in the matter was one of classroom discipline, a protocol possibly more suited to the constraints of factual recall questioning rather than the more liberal arrangement required for open-ended questioning:

> I didn't make any suggestions, the only thing I stressed was on the discipline side to make sure that when he asked the question, first of all that the students listened and that they put their hand up. (Interview with Peter)

Carlo used open interviewing with individual students to assess their understanding of the content of his lessons, and he was careful to point out that he viewed interviewing as something with a specific purpose, not just 'every interaction you have'. Interviewing was done on Carlo's own initiative, and not on the recommendation of his supervising teacher.

Carlo was not happy about the fact that he had to take mental arithmetic pencil-and-paper tests in every Year 8 lesson. While his supervising teacher did not recognise them as tests—as he claimed that Carlo did not administer any tests on his teaching practice—Carlo saw them as less of an assessment strategy and more as a means to obtain classroom order:

> The only thing I wasn't happy about was mental. You'd always have to do mental, come into class and do mental. And I'd take it. I suppose that defeats the purpose of it, but I suppose it's been done for years. That's just a strict pencil and paper test, but the teacher I had said that the Year 8s needed it, because they have to be structured. They have to be sitting down doing the work and have something they know they can do to start off with. (Interview with Carlo)

Carlo observed students using modelling as an assessment strategy, and while he participated in the activity, it was clearly not his own initiative. He described a modelling project which had been initiated some weeks prior to his commencement on teaching practice:

> In the modelling class they had to do a couple of reports. They had to design an outdoor area and discuss all the factors and stuff. They had a portfolio as well and a quick presentation. That was an ongoing thing. It took about 6 or 7 weeks and some holidays as well, because they had to go away and look at the prices of bricks and things. (Interview with Carlo)

Like Rowan, Carlo admitted to using self-assessment techniques only in the most casual manner, with just the occasional reflective prompt:

I used reflective prompts maybe. Like I'd ask the class sometimes, just basically 'What have you learned?' (Interview with Carlo)

Carlo's supervising teacher attributed this to lack of time, and pointed out that most of the assessment techniques used by Carlo were done in an informal manner. Again, Carlo seems to have capitalised on situations where he was free to implement strategies of his own choosing, although he appears not to have done this to the same extent as the other students in the study.

Zoe

The school in which Zoe completed her professional practice was a co-educational, government senior high school. She taught Years 8 and 10 mathematics under the supervision of James, and a Year 10 computing class with another teacher. Zoe's view of the assessment strategies she used on teaching practice are presented below in Table 9.5, together with a summary of the views of her supervising teacher.

Table 9.5:   Assessment strategies used by Zoe during professional practice

Source	Assessment strategies					
	Observing	Questioning	Interviewing	Testing	Reporting	Self-assessment
Zoe	Checklists for home-work Anecdotal records	Higher order	Open interviewing	None	Oral reports	None
Supervising teacher: James	None	Factual recall	Open interviewing	None	Oral reports	None

While her supervising teacher did not recognise that she was using this assessment strategy with the students, Zoe reported that she used both checklists and anecdotal records to assess students in her teaching practice, although she qualified the use of checklists as simply being a list against which to mark homework. Nevertheless, she appeared to have a good understanding of the use of anecdotal records, and used the technique in her classes:

If some kids didn't understand—I guess that's anecdotal records—I'd write little things like what mark they'd got and why they did pretty bad and I'd try to spend some time with them in the next lesson. So they were really helpful in that way. (Interview with Zoe).

Zoe appeared to have an excellent understanding of how to use higher-order questioning to determine whether students understood the procedures they were required to follow. For example, she explained how she used the strategy with Year 10 children:

> I'd explain to them what to do and start using the higher-order questions to see if they really understood what they were doing or just saying things to get rid of me. (Interview with Zoe)

While Zoe admitted that she had trouble with open-ended questions, and that they usually came out as 'And then we ...?', she claimed to use a lot of higher-order questioning in assessing students' understanding as opposed to simply getting the 'right' answer. Her supervising teacher complained about her reluctance to accept an answer without an explanation of its meaning:

> She'd get the kids to come up and put the answers on the board, which she probably overdid early on if anything ... Virtually every answer she got from the kids she would want them to justify on the board ... she probably took it too far. (Interview with James)

Both Zoe and her supervising teacher agreed that she used open interviewing assessment strategies with students. As Zoe described it: 'I'd sit there and say "Why did you do that?" and "What did you do next?"' James admitted that this was done on her own initiative but qualified this by insisting that such a technique would be standard practice in any classroom. Zoe did not initiate any pencil-and-paper tests, and was not required to administer any. The supervising teacher pointed out that all the tests were done the week after the professional practice finished, in the last week of the term.

Zoe used oral reporting by requiring students to present and defend their findings to the class. This was the only type of reporting she initiated. As pointed out by her supervising teacher, time constraints meant she could not attempt some of the more sustained types of assessment strategies:

> You're talking about a two week prac! They're really doing assessments that you've already set aside for them to do, and she came in a week where there weren't a lot of assessments to do. I'd say no, but not because she didn't want to, it was because it wasn't required. (Interview with James)

Zoe did not use any form of self-assessment with the students in her professional practice classes, although she pointed out: 'I could have, should have!' Zoe's general

interest in assessing her students was summed up by her supervising teacher who expressed surprise at her enthusiasm for marking:

> The only comment I have, which is a strange one, is that she was very keen to do marking. I'd like to talk to her about that in 10 years time but she was itching to do marking. The assignment was the only thing we had in that particular time frame, so I had to dig up a bit of intro calc just to keep her going. (Interview with James)

Generally, Zoe appeared to implement a variety of assessment strategies in areas that were under her control. As James pointed out, many of the assessment strategies had been planned in advance for the preservice visiting teachers leaving them very little choice. However, in areas where the students have some discretion, Zoe, like many of the other students in the study, was able to implement some of the strategies of her own choosing.

David

David's professional practice was conducted in a private non-government, co-educational school. During his teaching practice, he taught Year 8, 10 and 12 mathematics under the supervision of Frank. David's view of the assessment strategies he used is summarised in Table 9.6, together with the views of his supervising teacher.

Table 9.6:   Assessment strategies used by David during professional practice

Source	Assessment strategies					
	Observing	Questioning	Interviewing	Testing	Reporting	Self-assessment
David	Anecdotal	Higher-order questions	Open interviewing	Pencil and paper test	Getting students to explain their solutions to others on blackboard	Occasional reflective prompts
Supervising teacher: Frank	Anecdotal	Open ended questions	Open interviewing	Pencil and paper test	Getting students to explain their solutions to others on blackboard	None

David reported that he made use of observation techniques to assess students' understanding on the classes he taught during his professional practice. The technique used by David was anecdotal records and he described the process in the following manner:

> I did use anecdotal notes. Just little notes as I walked around. It was just observation, but you can't help but write things when you see them. (Interview with David)

David's supervising teacher was aware of his use of anecdotal records and expressed surprise at how effectively David used the technique, albeit in this example, not as a measure of understanding but effort:

> I saw evidence that he observed … I was worried at one point that he may not notice students not working, one in particular that I was concerned about. But he actually mentioned to me after the lesson 'Chris actually did some work, I checked'. He was identifying and monitoring on task on the spot. (Interview with Frank)

When asked what types of questioning David used during his teaching practice, Frank pointed out that effective questioning is a complex skill that needs a great deal of practice to perfect. David himself reported that he had used higher-order questioning, but that it wasn't specifically planned that way. Frank's comment indicated that while the intention to use questioning beyond the level of factual recall was there, and that David was as capable as one would expect, he needed time and practice to be able to use questioning effectively:

> He used open-ended questions but we talked about the need for them to be a bit specific and he's not at the stage—I probably wouldn't expect him to be at this stage of his practice—to be able to bounce questions from one student to another, and at no stage giving the answer but posing another and making them think. (Interview with Frank)

Both David and his supervising teacher reported that David used open interviewing techniques with students. David commented that if a student asked for help, he questioned them, rather than simply giving the answer. Frank was happy to encourage David to practise these techniques where he himself would have left the students to find out for themselves:

> There are times when I will actually not tell a kid something where I think they ought to go and find out themselves. He was more prepared to sit down with them and work it through. So I thought 'Well good, let him'. That was good practice for him, because that's where you get to see where the kids' concepts are up the creek and their thinking is not what you thought it was. (Interview with Frank)

David was required to give a test which had been designed by his supervising teacher. His contribution to the test was to prepare one question on graphing representations of data. David marked the test but was not in a position to give the test back to students or discuss the results. Both David and Frank agreed that the only reporting strategies used by David were oral reports of students' findings in lieu of providing the right answers:

> He did have students doing answers on the board for others. He used students to do work, instead of putting the answers up. (Interview with Frank)

When asked whether David used any self-assessment strategies with students, his supervising teacher reported that he did not and that he tended to concentrate on 'more fundamental skills'. David himself admitted that the only self-assessment he used in students' learning was to prompt the occasional reflective question:

> I guess self-questioning, say you know 'What's the question asking?', that sort of thing. (Interview with David)

Like all the students in the study, David was limited in the types of assessment strategies he could use. He was required to administer a pencil-and-paper test and other predetermined methods on the direction of his supervising teacher, but used more varied methods of assessment when he had the discretion to do so.

Prediction of assessment practices

At the conclusion of the students' use of the interactive multimedia program on assessment, a prediction was made that they would adopt the use of more appropriate assessment strategies than the ubiquitous pencil and paper test. While there was no attempt to assume a direct causal relationship between the assessment program and students' work on teaching practice, any other variables suggested as relevant in this procedure would add to the understanding of the processes involved and provide insight into additional contextual factors which affect learning.

The prediction, as written on the form for use with students in the follow-up interviews, was that:

> In your mathematics classes on your teaching practice, you will use a variety of assessment techniques to assess student learning, other than pencil and paper tests.

In the interviews, the students were given the prediction and asked to judge its accuracy, and the accuracy of the reasons given to justify it. Students were asked to read the prediction and then to describe what actually had happened on their professional practice with regard to assessment (Appendix 13).

Four of the students reported unequivocally that the prediction was true (Evie, Louise, Rowan and Zoe); one student was unsure, tending toward the negative (David); and one student stated that the prediction was not true (Carlo). Students were also asked to nominate the factors that were most important in leading to the actual situation, and these responses are summarised below in Table 9.7.

Table 9.7:   Factors nominated as important in prediction outcome

Student	Prediction true or false	Factors nominated as important in outcome
Evie	True	Authority of the teacher: 'I was virtually told what to do by the teacher, [the only choice was] the questioning type of assessment'
Louise	True	• Influence of supervising teacher: 'My supervising teacher, he always had mental for the girls, so I just followed on from that' • Own dislike of tests: 'I didn't like having tests in maths so I would rather it be more informal with discussion and questioning'
Rowan	True	• Authority of supervising teacher: 'The teacher saying what to do was the most important [but] I used a lot more observations than I would have'
Carlo	Not true	• Authority of supervising teacher: 'I'm not the qualified teacher. I'm in their situation, in their room, conforming to their rules'
Zoe	True	• Influence of supervising teacher: 'Because they were having tests the week after I finished teaching there, he wanted to do revision'
David	Unsure	• Comfortable with pencil and paper tests: 'It was the way I was used to doing it. I'd give the pencil and paper tests'

Students were also given prepared lists of factors which might have supported the prediction coming true and factors working against, and asked to nominate the relative importance of each (Appendix 14). The purpose of asking students to nominate their own list of factors prior to being shown this list was to avoid contamination by the viewpoint of the researcher. When shown the additional lists of factors, students were asked to state whether each factor was *Important, Relevant but not important* or *Not relevant* to their adoption of, or failure to adopt, a variety of assessment strategies in the mathematics classes they taught. The factors suggested to the students as factors which might have supported the prediction coming true were:

- Encouragement and support from supervising teacher,

- Sufficient time to plan lessons carefully,

- Aware of other strategies from observing other teachers on professional practice,

- Aware of other strategies from using the multimedia program on assessment,

- Aware of other strategies from the methods you experienced as a student yourself.

The students' nomination of the importance of each of these factors, together with summarising comments are presented below in Table 9.8.

Table 9.8: Students' assessment of factors which might have supported the prediction

Relevance	Encouragement from supervising teacher	Sufficient time	Strategies from other teachers	Strategies from IMM program	Strategies from own schooling
Important factor	Evie: 'It was important' Louise: 'He let me do what I wanted to and gave me ideas if I needed them' Rowan: 'They gave plenty of support and encouragement to the way they wanted it done' Carlo: 'Definitely relevant' David: 'Yes, he's the one who's going to be marking you so you do what he or she says'	Evie: 'It was an important factor' Louise: 'I had a lot of time to plan my lessons, so I knew what I wanted to do' Rowan: 'You need sufficient time to plan assessment during the lesson, or a series of lessons' Zoe: 'Yes it was important'	Zoe: 'I have seen a few teachers and a lot of different strategies and I think, wow, that works really well!'	Evie: 'I got the ideas from the multimedia and tried to implement them' Louise: 'Not consciously, but probably unconsciously' Rowan: 'The whole time I was on prac I was actually thinking about different assessment strategies' Zoe: 'Yes it was a really important factor'	Louise: 'I had Ms x as my teacher and she's into a lot of discussion and explaining, not so much testing' Zoe: 'Yes, that's important too'
Relevant, but not important	Zoe: 'He didn't say much at all to me, he'd just say if a lesson went wrong'	Carlo: 'We had sufficient time' David: 'If you're going to write a test you need time'	Louise: 'Just a few from my supervising teacher' Rowan: 'It can influence you negatively'	Carlo: 'I would have liked to have looked at it again. We only did it briefly, just the three weeks'	Carlo: 'You tend to teach like the teachers you liked. It's human' David: 'Yes, I do that'
Not relevant			Evie: 'I didn't get a chance to observe others' Carlo: 'Not relevant really' David: 'No not unless it was something completely different'	David: 'You do things for a grade, not so you can put into practice what you've learned'	Evie: 'I didn't agree with the methods my teachers used so I did the opposite' Rowan: 'I think I'd try to teach differently to the way I was taught'

Students were also given a list of factors which might have worked against the prediction coming true, that is, that the students used mainly pencil and paper tests to assess students in their mathematics lessons. These were:

- Supervising teacher dictated the type of assessment for each lesson,

- Not aware of any other strategies that were appropriate,

- Pencil and paper is best for grading purposes on teaching practice, because any other method is too difficult to follow up,

- Not enough time to prepare a variety of assessment techniques,

- There is no need for assessment of learning in classes taught during teaching practice.

Students' responses to these factors are summarised in Table 9.9 below.

Table 9.9:   Students' assessment of factors which might have worked against the prediction

Relevance	Supervising teacher dictated assessment	Not aware of other strategies to use	Belief that pencil and paper is best	Insufficient time	No need for assessment on teaching prac
Important factor	Evie: 'Yes, that's true' David: 'The teacher's the one doing the marking' Rowan: 'For most it was a pencil and paper test. It's how they've always gone about it'			Rowan: ' Some of those assessment techniques you need time to actually use it' Zoe: 'That was important'	
Relevant, but not important	Carlo: 'Basically, he'd just ask me: What do you think? All my assessment was done informally' Zoe: 'It was relevant, but it didn't happen all the time'		Rowan: 'It is quite difficult to follow up in 2 weeks' Zoe: 'When you don't know the students' names, they can be quite useful' David: 'You can do a whole class at a time'	Carlo: 'It was up to me. I had to make time if I wanted to' David: 'Relevant'	David: 'In a 2 week prac it's not that important'

Relevance	Supervising teacher dictated assessment	Not aware of other strategies to use	Belief that pencil and paper is best	Insufficient time	No need for assessment on teaching prac
Not relevant	Louise: 'Not at all'	Evie: 'It wasn't that I wasn't aware' Louise: 'If I didn't use them, I didn't connect them with that lesson' Rowan: 'Not relevant because I am aware' Carlo: 'I wasn't trying to incorporate everything' David: 'No' Zoe: 'Not relevant'	Evie: 'I don't think pencil and paper is best' Louise: 'You've got limited time but I think pencil and paper just creates too much difficulty for students' Carlo: 'That's a bit bold to say that'	Evie: 'Not relevant' Louise: 'No not relevant'	Evie: 'It is important for assessment of learning' Louise: 'Maybe not formal, but questioning and monitoring is important' Rowan: 'There is a need. You need to know where the students are at' Carlo: 'No, you definitely should have a look' Zoe: 'Not relevant'

The prediction was made that the students would use a variety of assessment techniques in their mathematics classes during teaching practice, and this was true of all six students. In spite of the fact that one student reported the prediction to be untrue and another was unsure, all the students did use a variety of strategies. Evidence to support this conclusion was provided by the students on their own admission in interviews, and this was generally corroborated by their supervising teachers.

If students had used only pencil and paper tests to assess students, only *Testing* strategies would have been used. However, as shown in Tables 9.1–9.6, all the students used assessment strategies from the *Questioning* and *Interviewing* groups of strategies, most used *Observing* and *Testing,* and some students used *Reporting* and *Self-assessment* strategies. Generally, the students used the assessment strategies that had been predetermined for use by the supervising teacher. However, this was supplemented by the use of strategies that were under the students' own control.

Several other salient issues emerged from the analysis of the prediction data which relate to the investigation into whether students' learning from the interactive multimedia program on assessment transferred to classroom practice. These issues concern transfer as integral to students' cognitive structure, the influence of the supervising teacher, the students' critical appraisal of exemplary teaching, the limited time allowed for the professional practice, and the influence of the interactive

multimedia program. Each of these interrelated issues is discussed in more detail in the sections that follow.

Transfer as integral to students' cognitive structure

As described in Chapter 2, a situated learning view of transfer is not one that suggests that a person can acquire a set of skills which can be lifted and applied in a totally novel situation. The view of transfer adopted by the proponents of situated learning and used here, is that knowledge is more likely to be transferred to novel situations when it is learnt in the context of use and is 'a central or integral part of one's cognitive structure' (Prawat, 1992, p. 375).

It appeared from analysis of the comments made by students in the transfer study that assessment issues had been incorporated into students' cognitive structures. They spoke openly and knowledgably about assessment issues after their teaching practice, in a manner which substantiated Brown, Collins and Duguid's (1989b) claim that new situations enable knowledge to be recast 'in a new more densely textured form' (p. 33). The students acknowledged the complexity of the area but were well acquainted with the types of assessment which might be suitable in the mathematics classroom, and they used appropriate language with familiarity and ease. As shown in Table 9.9, none of the students thought that being unaware of appropriate assessment strategies was a relevant factor in their teaching practice.

The students were also aware of the usefulness of assessment in performing more functions than the summative appraisal of students' understanding. Writers in the mathematics education area (e.g., Burton, 1992; Clarke, 1988; National Council of Teachers of Mathematics, 1995; Kroll, et al., 1992) have listed many purposes of assessment, and these are summarised in Table 9.10.

Table 9.10:   Purposes of assessment in mathematics

Burton (1992)	NCTM (1995)	Clarke (1988)	Kroll, Masingila & Mau (1992)
To inform the learner	To monitor students' progress	To inform the pupil of identified strengths and weaknesses	To make decisions about the content and methods of instruction
To inform the teacher	To make instructional decisions	To improve the teaching of the child	To make decisions about the classroom climate
To inform the next educational stage	To evaluate the instructional program	To improve the teaching of the lesson	To help in communicating what is important
To inform employers	To evaluate students' achievement	To inform subsequent teachers of the child's competencies	To assign grades
		To inform parents of their child's progress	

The various roles of assessment were not explicitly listed in the interactive multimedia program but were intrinsic to much of the comment by experts and teachers, and demonstrated in many of the scenarios. Comments by the majority of students indicated that they were aware of many important roles for assessment, and that it could be used, as noted by Jonassen (1991b) as 'less of a reinforcement or behaviour control tool and more of a self-analysis and metacognitive tool' (p. 32). For example, Louise commented on 'formal' and 'informal' assessment when asked whether assessment was necessary on short professional practice:

> It depends what you mean by assessment. Like when we used the multimedia, they looked at questioning and monitoring as part of assessment and some people don't think that is assessment. So I think maybe formal assessments like maybe long investigations where a lot of work is done, maybe that's not necessary, but I think the informal like questioning and monitoring is. (Interview with Louise)

Rowan also pointed out that assessment has a critical role in helping him to monitor his own performance as a teacher:

> As a teacher, you need to know where they're at and the objectives you're setting yourself to start off with. I think it's quite important really because you have a feel for how you're doing, especially if you can see that they're learning something, it actually allows you to assess your own teaching. (Interview with Rowan)

The students were able to speak knowledgably and confidently about the issue of assessment which appears to support the view that they had incorporated their learning into their cognitive structure. Lave and Wenger (1991) point out that learning

the language and stories of a community of practice is necessary for full participation in that practice, and the students' ability to speak both within and about the practice was clearly evident in their discussion.

Influence of supervising teacher

The most frequently cited influence for the use or non-use of a variety of assessment strategies was that of the supervising teacher. One student summed up the difficulties associated with professional practice under the guidance of an experienced teacher:

> The hardest thing about a two week prac is that teachers say assess them in this way so that's what you have to assess. So you don't get much of a chance to put things into practice. (Interview with Rowan)

While in some cases the influence of the teacher was a positive element in the students' use of a varied array of assessment strategies, in many cases it was the overriding influence in the way the student conducted the classes. For example, David's comment demonstrates that the supervising teacher's appraisal was paramount to a successful professional practice:

> He's the one that going to be marking you so you do what he or she says. Yes. I'd say that's a very important factor. (Interview with David)

Several of the students pointed out that the methods used by their supervising teachers were possibly simply routine, that they no longer thought about the strategies they used and they applied them mechanically almost by habit. Rowan expressed a very strong opinion about the techniques used by his supervising teachers:

> The end assessment, I think for most of them was a paper and pencil test. It's how they've always gone about it, it's just ingrained. (Interview with Rowan)

When questioned about whether he had tried to influence the types of assessment used Rowan also pointed out that the supervising teachers were open to change:

> When they offer suggestions, I try to offer other suggestions back, just little queries here and there like 'Would this be a good idea?' and they'd come up with 'Oh yes, that sounds good'. I'd go about it that way. I had a few times where that happened. (Interview with Rowan)

However, this was not the experience of all the students. The following comment described the feeling of powerlessness and lack of ownership felt by one of the students operating in what was effectively, another teacher's classroom:

I'm not the qualified teacher. I'm in their situation, in their room, conforming to their rules. So you can't just suddenly say 'Hey, let's do some oral assessment'. (Interview with Carlo)

Many of the students were inhibited in the choice of assessment strategies by the influence and authority of their supervising teachers, in a way which would not have been an issue if the students were practising teachers with their own classes.

Limited time for teaching practice

The professional practice period following the use of the multimedia program on assessment was used to gather data on whether students used a variety of assessment techniques, or whether they reverted to the more traditional use of paper and pencil tests. This practice comprised just two weeks in a metropolitan secondary school for all the students, a period of time which was inadequate for the use of many of the assessment strategies presented in the multimedia program. All the students and many of the supervisors agreed that some of the more comprehensive and ongoing types of assessments such as journals, modelling and portfolios required a significant and sustained commitment over a substantial period of time.

Several of the students indicated problems with assessment during such a short teaching practice. Zoe pointed out that she did not even know the names of the students at the end of the two weeks, and used this as an argument for the usefulness of paper and pencil tests. David also pointed out that when time is an important factor, pencil and paper tests are efficient:

It's pretty good because of the time. You can do a whole class of students at once, and I wouldn't say its the best but it's certainly a good one. (Interview with David)

Rowan commented that the time limit was a relevant factor in his choice of assessment strategies:

Some of those assessment techniques you need time to actually use it, whereas a pencil and paper test is very easy. You just go bang. Some of the other ones, like anecdotal records and things need a period of time. They can't be done in two weeks. (Interview with Rowan)

The two week time span appeared to severely restrict the choice of assessment strategies available to the students on professional practice. Students tended to employ strategies which could be done in a limited time span which meant that the more time-consuming strategies such as journals and portfolios were unsuitable.

Critical appraisal of exemplary teaching

One of the principal challenges of teacher educators is to promote that view that teachers can be purposeful in the methods they use, and that they do not have to limit themselves to methods they learnt as school children from their own teachers—the view that 'you teach as you were taught' (Australian Education Council, 1991). An interesting issue to emerge from the analysis of the data on transfer was the manner in which students critically appraised both their own school teachers and other teachers they observed in teacher training. One student admitted to being influenced by his own school experience to the point where he found himself using the same style:

> You tend to teach like the teachers you liked, and in the ways you liked. It may not be correct but being human, it's just realistic. (interview with Carlo)

However, most of the students evaluated the experience more critically, some to the point of being determined to do the opposite:

> I didn't agree with a lot of methods that my teachers used when I was a student so I virtually did the opposite to what they had done. (Interview with Evie)

Similarly, Rowan was not influenced positively by his school experience of learning mathematics:

> I think I'd actually try to teach differently to the way I was taught. It was very much like a test every week when I went through school. (Interview with Rowan)

Not all the students' school teachers were used as negative role models. One student reported that she was very positively influenced by her mathematics teacher:

> I had Ms. X as my teacher when I was at school, and she's into a lot of discussion and explaining, not so much into the testing, like trying to get you to understand rather than assess in formal ways. So I think because I was able to succeed that way I try to pass that on to teaching now. (Interview with Louise)

Students also evaluated other teaching they observed on their professional practice. Some were positively influenced by the experience, some negatively. For example, one student expressed a critical view of the habits of many practising teachers:

> It can influence, quite negatively actually, because the majority of teachers assess just with pencil and paper tests. It can encourage you to fall into the trap of accepting that it's just how it's got to be. (Interview with Rowan)

Another student pointed out that he would not use another teacher's methods 'unless it was something completely different, really different' (Interview with David). Some students, however, saw a real value in observing and learning from experienced teachers:

> It's an important factor, because I have seen a few teachers and a lot of different strategies and I think 'Oh wow, that works really well'. (Interview with Zoe)

Generally, the students in the study were active in choosing the methods of teaching and assessment they used on their teaching practice. With the exception of one student who expressed the view that it is human nature to teach as you've been taught, most critically appraised both their own school experiences and exposure to other teachers and were not blindly duplicating either in their professional practice teaching.

Influence of interactive multimedia program on assessment

The fact that the prediction was true and students used a variety of assessment strategies may or may not have been due to the influence of the interactive multimedia program on assessment. There is no firm evidence to assume a causal relationship between the two. It is possible, however, to assess students' own beliefs about the program and its impact on their teaching performance.

The majority of students believed that their use of the interactive multimedia program on assessment was a direct and important influence on their use of assessment strategies during their professional teaching practice. One student was the exception by stating that the program had no effect on his teaching and was irrelevant to his choice of assessment strategies:

> You do things for a grade, not so you can put into practice what you've learned. There wasn't anything explicitly, mentally where I'd think 'I have to do this next' it was all just off the cuff. (Interview with David)

This fairly glib response is enlightened by David's supervising teacher who reported that David, in spite of the facade, was a capable and imaginative teacher, who put a lot of thought into his lessons:

> I need I think to go a little bit into David's personality. David's a fairly quiet sort of a chap and it took me a day or two to work out that processes were going on inside his head even though he wasn't saying anything ... But it's amazing, he had some really imaginative ideas in terms of relating to the class and making the actual content more interesting. (Interview with Frank)

The remaining students all attributed the interactive multimedia program as an influence in their adoption of assessment strategies, albeit to varying degrees. One student believed that the program was a very important influence:

> I think it influenced me greatly, I really took it to heart. So I basically did implement a lot of the assessment types that were identified in the multimedia. I think it was a really big help in that part. (Interview with Evie)

Another student pointed out how the program influenced his thinking as he prepared his lesson plans:

> It made me think about assessment a lot more, each time I was writing up a lesson plan. Each time I came to assessment, I thought about it a lot more. It was a case of, 'Well I wouldn't want to end up doing a pencil and paper test, so how am I going to structure assessment while I'm here doing this series of lessons?' I was a lot more conscious of it. (Interview with Rowan)

Like Rowan, other students also referred to consciously reflecting on assessment as a result of using the assessment program. For example, Zoe made the following comment which also reflects her concern about the excessive use of pencil and paper tests by her supervising teacher:

> It's opened my eyes a lot more, like on the pencil and paper tests and also watching my teacher and really disagreeing with a lot of the assessment strategies he'd use. He only used pencil and paper assessment strategies. Of course I didn't say anything, but I'd sit there thinking 'Oh remember what we learnt'. (Interview with Zoe)

Interestingly, some of the students spoke about using the assessment strategies from the interactive multimedia program almost unconsciously. For example, Carlo admitted that he may have been influenced to use strategies without consciously knowing it. Similarly, Louise commented that her use of the strategies was unconscious but then went on to describe a very thoughtful and reflective response to children's concerns about assessment:

> It probably wasn't conscious, I was doing it unconsciously. I was trying to use a variety of things like the questioning and the observing and things like that rather than say 'If you didn't get that correct, that's wrong!' Rather I'd say 'What if you did it this way?' I'd try to use the assessment strategies that made the students feel more comfortable and so knowing which ones were less threatening, other than pencil and paper, made me think about what I wanted to do, and helped me to find out if there was a particular thing that the students could do. I thought about which method would be the best for finding that out. (Interview with Louise)

Several students expressed the view that in their future practice as qualified teachers they would be able to exercise greater discretion in their use of assessment strategies. For example, the following comment was typical of five students' views:

> There were only limited types of assessment that I could use, but hopefully in the future I'll be able to use a wider range of the ones that were on the multimedia. Hopefully I'll be able to ... start journals and things like that. (Interview with Evie)

An important issue relating to transfer was raised by one student who had a double major and was studying both mathematics and language method. She pointed out that it was possible for her to transfer her learning about assessment strategies to other subject domains:

> It's based on maths, the multimedia one was, but I would probably think that it could be applied to anything. It's more general. I found myself using some of these techniques in my other classes, like English. I thought they helped if you look at them in a general view, not just for maths. (Interview with Louise)

According to the beliefs of the students themselves, the multimedia program on assessment appeared to influence the types of strategies they employed and their thinking about assessment as they taught mathematics and other classes during their professional practice in schools.

Discussion

The transfer study set out to investigate whether students' learning from the interactive multimedia program on assessment transferred to classroom practice on their professional practice in schools.

Analysis of the data shows that all the students could speak knowledgably and confidently about assessment, and all the students used a variety of techniques to assess children's understanding. The students appeared to be influenced very strongly in their use of assessment strategies by the supervising teacher. However, even when assessments had been planned in advance, all students used techniques that they were able to use without the contribution or agreement of the supervising teacher. Five of the six students attributed their use of assessment techniques to the interactive multimedia program.

Two factors mitigated against a realistic appraisal of whether the students' use of the assessment program influenced their adoption of a variety of assessment practices in a real-life classroom:

1.   The substantial influence of the supervising teacher

2.   The brevity of a two week professional practice.

Ideally, the students needed to be appraised in the real world context, possibly in their first or second year as practising teachers, and over a lengthy period of time. However, this scenario also presented problems. As second year students, their fulltime employment was over two years away, and there was no guarantee that the students would either complete the course or find employment at the end of it.

The choice of the professional practice nearest to the use of the interactive multimedia program meant that any transfer effect could more reliably be attributed to the influence of the situated learning environment on assessment rather than an accumulation of influences and practice in the students' entire course. It also meant that the duration of the research could be maintained within a manageable time frame. The opportunity may exist, however, to conduct a follow-up study with these six students, if and when they find fulltime employment as teachers.

Resnick (1996) has recently been critical of one aspect of the situated learning model which she perceives as problematic: the disappearance of the individual. According to Resnick: 'Individual knowledge and skill—characteristics of individuals that can be carried with them from one situation to another—are replaced by emergent cognition that belongs to no one and disappears when the moment of emergence has passed' (p. 41). The findings of this study, within the parameters of transfer given here, refute this assertion. The students had clearly internalised the assessment issues investigated within the situated learning environment, and were able to use them competently in situations where they had the discretion to do so lending firm support to Vygotsky (cited in Wertsch, 1985b) who maintains: 'Any higher mental function was external because it was social at some point before becoming an internal, truly mental function' (p. 62).

Conclusions

This chapter begins with a summary of the research and a discussion of findings. The chapter also describes the limitations of the study and concludes with recommendations for further research. The thesis describes the conduct and findings of an interpretivist, qualitative study into how students learn from interactive multimedia based on a situated learning model of instructional design. Patton (1990) notes that: 'The description and rigor of qualitative analysis depend on presenting solid descriptive data, what is often called "thick description" ... in such a way that others reading the results can understand and draw their own interpretations (p. 375). A deliberate attempt has been made in the thesis to provide such 'thick description' and in many instances, to provide the words of the participants to express the meaning and beliefs behind their experience. In this way the thesis can provide not only an interpretation of the research, but also enable the reader to evaluate the potential appropriateness for other settings, and to have a 'vicarious presence' (Miles & Huberman, 1994, p. 279).

Summary of the study

Nine critical characteristics of a situated learning model were defined, based on the extensive literature on situated learning. Each of these characteristics was also researched in its own right. An interactive multimedia learning environment for university level students was designed according to the characteristics of a situated learning model established in Part A of the study. The learning environment included an interactive multimedia program on assessment in mathematics, together with recommended implementation conditions in the classroom.

A pilot study was conducted to test the feasibility of the research and the data collection methods. Two students were videotaped using the interactive multimedia program and later interviewed. Data collected from the study was used to begin the process of designing a framework for analysis of higher-order thinking as students used the multimedia program. It also enabled refinement of the program itself.

A more extensive study was then conducted with six students who were observed and videotaped using the interactive multimedia resource over a period of three weeks, and were later interviewed. Data were collected which enabled investigation of the way students use interactive multimedia based on a situated learning model, how they responded to the critical elements of the situated learning environment and whether they used higher-order thinking as they worked with the program.

The final study in the research investigated to what extent students used assessment strategies in the mathematics classes they taught during professional practice in schools after their use of the interactive multimedia program on assessment. Supervising teachers in schools were interviewed, and students were also interviewed using a prediction technique and interview schedule.

An overview of the conduct of the research and presentation in the thesis is presented in Figure 10.1 below.
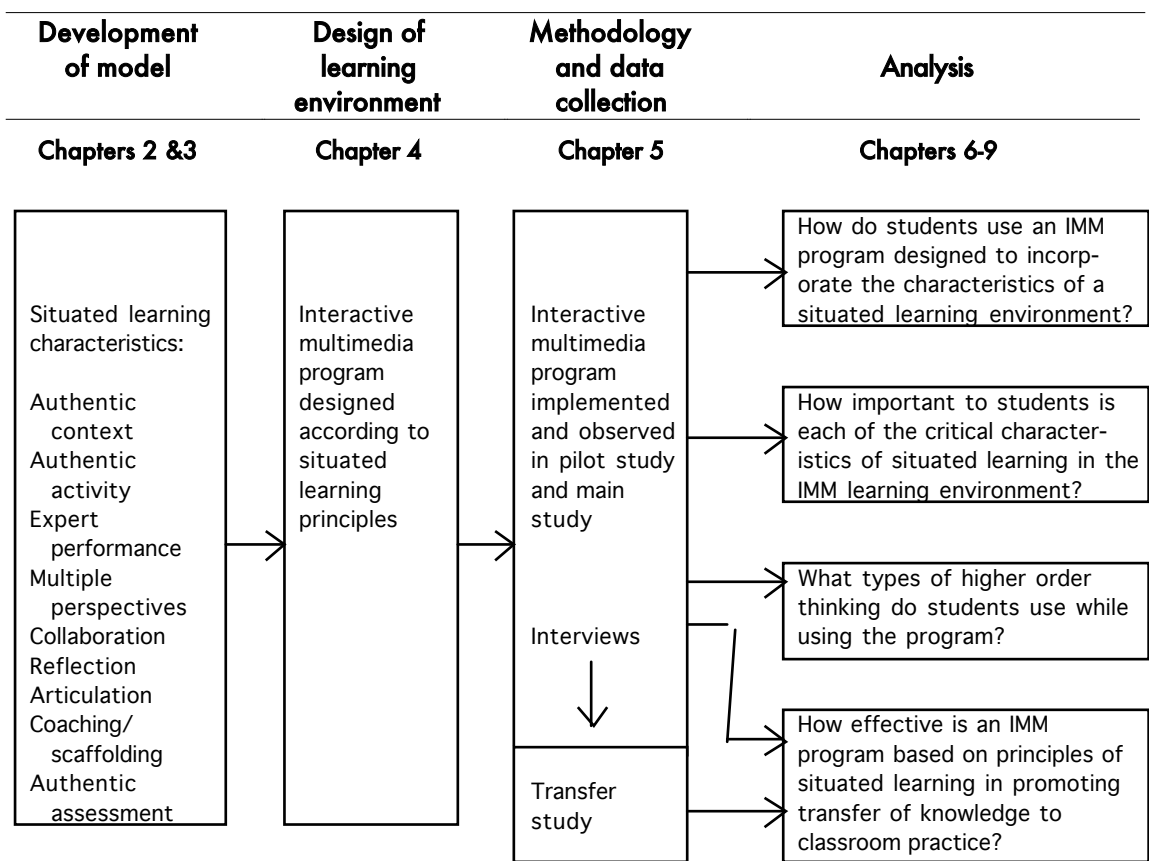
Development of model	Design of learning environment	Methodology and data collection	Analysis
Chapters 2 &3	Chapter 4	Chapter 5	Chapters 6-9

Situated learning characteristics:

Authentic context
Authentic activity
Expert performance
Multiple perspectives
Collaboration
Reflection
Articulation
Coaching/ scaffolding
Authentic assessment

Interactive multimedia program designed according to situated learning principles

Interactive multimedia program implemented and observed in pilot study and main study

Interviews

Transfer study

How do students use an IMM program designed to incorporate the characteristics of a situated learning environment?

How important to students is each of the critical characteristics of situated learning in the IMM learning environment?

What types of higher order thinking do students use while using the program?

How effective is an IMM program based on principles of situated learning in promoting transfer of knowledge to classroom practice?

Figure 10.1: Overview of the research

Findings of the studies

Research question 1

The findings related to the first research question: *How do students use an interactive multimedia program designed to incorporate the characteristics of a situated learning environment?* were that generally, students used the interactive multimedia program based on situated learning very differently to the way they might use some other types of computer-based resources, such as computer games and the Internet. The students reported experiencing a sense of magic and amazement at what they were able to do with the program, and while this may be attributable to the novelty value of interactive multimedia, it assisted their motivation in completing the task. Most of the students found the learning environment motivating and, in addition to the novelty aspects of the program, they attributed this to the fact that they worked with a partner, they could work at their own pace, and the authentic assessment of the task.

Students responded very positively to the ecological or intuitive interface design and the fact that they were able to freely navigate the resource to access the media elements. They had very little trouble acquainting themselves with the referential navigation system and used it effectively to investigate the resource. Search strategies employed by students varied considerably between groups, although all the groups approached the task systematically rather than randomly. In using the program, students spent little time on typing or clicking, but large amounts of time were spent reflecting and discussing issues with their partners. The ease of access of the notebook helped to facilitate students' ability to reflect on their learning. Some aspects of the program caused some annoyance, such as the small size of the video picture, and students also expressed feelings of irritation in dealing with technical problems largely related to computer-technology per se rather than the software itself. However, neither of these negative aspects were directly related to the situated learning model nor any of its essential characteristics.

These findings suggest that the use of the situated learning model was a successful alternative to the systems model frequently used for the development of interactive multimedia, one that enabled students to freely navigate a complex resource, and to access material in the order of their choosing.

Research question 2

The second research question: *How important to students is each of the critical characteristics of situated learning in the interactive multimedia learning environment?* investigated students' views and beliefs about each of the situated learning characteristics.

The findings suggest that *authentic context* is a crucial link between theory and practice at university, where students generally perceive theory to be relatively unimportant, and practice as critical to their effective training as teachers. The students appreciated the real-life context presented in the interactive multimedia program, and compared it favourably to their views of the alternative pedagogical methods they frequently encounter at university, such as learning by transmission. While the students were always aware that the situation was not real experience in classrooms, they perceived the situations to be very life like. They did not feel overwhelmed by the complexity of the resource. On the contrary, they perceived the resource to be very simple, and that their learning was frequently achieved without conscious effort. While the context of the classroom was authentic for the group of students using the resource, its portability into other cultures is an area that warrants further investigation.

The *authentic activity* provided students with a meaningful purpose for exploration of the multimedia program, and its complexity ensured that students had to define a course of action without recourse to 'sub-optimal schemes' for determining what the question was asking. The findings suggest that provided it is ill-defined and complex, an authentic activity is a crucial aspect of a situated learning environment and one which facilitates a sustained investigation of the resource.

The findings suggest that the *expert performance* students valued most highly was that of the practising teachers who demonstrated assessment techniques in the video clips. The students not only learned skills overtly from these videotaped demonstrations, but they also learned peripheral knowledge about the culture and conduct of the mathematics classroom. Preservice teachers' reflections also served as a useful measure against which the students could gauge their own understanding of the issues. However, the expert comment was accessed less frequently by the students. Such expert comment may have greater value in the more reflective stages of an investigation.

The findings suggest that *multiple perspectives* can be provided for in at least three ways in an interactive multimedia program based on situated learning. Firstly, students can be given opinions and thoughts from different parties within the program itself;

secondly, they can be exposed to others' unique perspectives by working in collaborative groups; and thirdly, they can be required to approach the same material from different perspectives through the task they complete as they use the multimedia resource. The non-linear navigation of the interactive multimedia program enabled the students to 'criss-cross' the resource with ease, and facilitated their visiting and re-visiting individual elements.

The characteristic of *collaboration*, and its implementation as collaborative dyads in the study, appeared to provide a multitude of advantages for students working in a complex learning environment. Collaboration appears to be a pivotal element in the situated learning model, and one upon which many of the other elements depend for their execution. There were many observable benefits for the students, such as joint-problem solving, the necessity to negotiate their learning, and the creation of a finished product that was of high quality. Several students alluded to problems that can occur in group work, such as unfair division of labour and interpersonal conflict, but none was evident in the study. The findings suggest that students benefit from the opportunity to articulate, reflect and scaffold with a partner, and that they will seek these opportunities covertly if they are not provided legitimately within the learning environment.

The principal design features to embody *reflection* were an authentic context and an authentic task to enable students to reflect in an engaging and captivating learning environment, rather than as a response to external cues or reminders. The learning environment allowed students to freely reflect on their learning by providing them with a multimedia program and collaborative working arrangement that enabled them to return to experiences, attend to feelings and to re-evaluate the experience. The students were able to share their reflections with each other and to use the notebook facility to conveniently record them.

The findings on *articulation* suggest that the opportunity to verbalise thoughts in small collaborative groups enabled students to be aware of their learning and to make appropriate links to incorporate it into their cognitive framework. The formal presentation to the class was a valuable opportunity to articulate and defend their understanding of assessment strategies.

The findings show that *coaching and scaffolding* can be provided not only by the teacher, but also by the student's partner in the collaborative groups. The role provided by the teacher was principally related to procedural matters of both content and software, whereas the role provided by the student partner was frequently fundamental to the

learning process, and provided considerable higher-order support. Both sources of support were valued highly by the students.

The characteristic of *authentic assessment* required students to be assessed in a real-life, if simulated, context that was fully integrated into their working practice as they used the multimedia program. The assessment gave the students the opportunity to be effective performers with acquired knowledge, and to present polished performances, which they felt they might be required to perform as teachers. Students had the opportunity to spend a significant amount of time on the preparation of their response, yet most felt that the time allocation was insufficient indicating that a sustained effort was made. Some students expressed the view that they felt more comfortable with traditional forms of assessment, such as essays and tests, but nevertheless they responded well to the complex and ill-structured challenge of the authentic assessment. The findings suggest that authentic assessment can be used successfully with interactive multimedia, albeit not encapsulated with the software itself, but as part of the learning environment.

Generally, the situated learning framework used for the design of the assessment program appears to be a successful alternative model of instructional design for interactive multimedia learning environments. This study lends support to Jonassen's (1991b) claim that situated learning is an effective instructional paradigm for advanced knowledge acquisition. When implemented with all the characteristics defined in the model, it appears to provide an effective framework for the design of an environment for the acquisition of complex knowledge, without the need for interventionist strategies or predetermined feedback.

Research question 3

In order to answer the third research question: *What types of higher-order thinking do students employ while using an interactive multimedia program based on principles of situated learning?* it was necessary to record students' talk as they used the multimedia program, and then transcribe and analyse that talk with the use of a classification scheme. All the students demonstrated a substantial proportion of higher-order thinking in their talk as they used the multimedia program on assessment. The high level of higher-order thinking amongst all the groups meant that there was a substantial number of units of meaning in students' talk which could be classified according to the classification scheme. Each unit of meaning was categorised as *Uncertainty, Path of action, Judgement, Multiple perspectives, Imposing meaning* or *Metacognition*.

The findings show that students used a substantial amount of higher-order thinking, relatively little social and lower order talk, and a moderate amount of procedural talk as they worked with the assessment program. In all the groups, *Uncertainty, Path of action* and *Judgement* comprised the major part of their talk, with the other classifications making up the remainder. Of the higher-order talk recorded, interesting variations in proportions were evident between the groups, suggesting that factors such as social ease with partners and a past history of collaboration may contribute to the quality of the discussion and the amount of higher-order thinking that occurs in groups. The variations in talk where students brought different perspectives to the discussion, by challenging or arguing with each other or the program, appeared to have different outcomes: a high incidence of *Multiple perspectives* led one group accordingly to a higher incidence of *Imposing meaning*, the other group did not. Further investigation of this occurrence would be enlightening. In all the groups, students' expression of metacognitive awareness was minimal, and it is possible that this is a type of thinking which does not manifest in the spoken word as well as the other categories of talk. No sequence or pattern was evident in the types of talk employed by the students. There was no evident progression from social to procedural to higher order. Groups were just as likely to use any type of talk at any time.

All the groups observed in the study recorded a greater degree of higher-order thinking than other types combined. Of the higher-order thinking, all the groups used a considerable amount of talk which fell into the categories of *Uncertainty* and *Path of action* categories, although there were substantial variations between the groups.

Research question 4

The fourth research question was: *How effective is an interactive multimedia program based on principles of situated learning in promoting transfer of knowledge to classroom practice?* In order to answer the question, a prediction was made that students would use a variety of assessment techniques to assess student learning, other than pencil and paper tests. For the majority of students the prediction was true, and all the students exhibited a further characteristic of transfer defined by the Cognition and Technology Group at Vanderbilt (1993a): they were able to speak knowledgably and confidently about the issue of assessment which appears to support the view that they had incorporated their learning deeply into their cognitive structures.

Two factors influenced students' use of assessment strategies during their teaching practice. Firstly, a limited two-week professional practice period appeared to severely restrict the choice of assessment strategies available to the students on professional

practice. Secondly, the students appeared to be influenced very strongly in their use of assessment strategies by the supervising teacher. Nevertheless, the students had clearly internalised the assessment issues investigated within the situated learning environment, and were able to use them competently in situations where they had the discretion to do so. According to the beliefs of the students themselves, the multimedia program on assessment appeared to influence the types of strategies they employed and their thinking about assessment as they taught mathematics and other classes during their professional practice in schools.

There was no intention to establish a direct causal relationship between the assessment multimedia program and students' work on teaching practice. However, their own reports of the program's impact, together with the other variables suggested in the research, add to the understanding of the processes involved and provide insight into additional contextual factors which affect learning.

Implications of the research

Eisner (1991) pointed out that the highly context-specific nature of educational life means that researchers cannot provide teachers with ready-made solutions to their particular problems:

> The researcher might say something like this: 'This is what I did and this is what I think it means. Does it have any bearing on your situation?' ... Researchers are not the ones to provide rules of procedures to practitioners; there are no sacred seven steps to effective teaching. We offer considerations to be shared and discussed, reflected upon and debated. (pp. 204-205)

With research such as reported here, it is the practitioner—the multimedia developers, instructional designers, lecturers and students—who must judge the applicability of the findings and recommendations made. There are many implications for practice in the findings of this research, and some of the more salient are described below. Most relate directly to the use of interactive multimedia in the tertiary sector, although some will apply to other areas. The implications apply to both the design of interactive multimedia and its implementation in the learning environment.

Implications for the design of interactive multimedia

The principal implication for designers of interactive multimedia programs is that new learning theory *can* inform the instructional design of interactive multimedia. For

implementation in contexts of advanced knowledge acquisition, an instructional design model based on situated learning is an effective substitute for the traditional instructional systems design model. Contrary to assertions by Dick (1995) that constructivist models may lose the emphasis on instruction and result in 'mere edutainment or infotainment' (p. 10), the interactive multimedia program on assessment placed the emphasis, not on instruction, but on learning. In so doing, it created an environment where students used higher-order thinking, in collaborative groups, to learn strategies of assessment in mathematics that were able to transfer to teaching practice. The nine, non-sequential elements of the situated learning model may guide designers of interactive multimedia to a model based on constructivist values and recent learning theory. Further research may help to refine the nine characteristics.

A further implication of the current research is that excessive intervention by the developer in providing interaction between the program and the learner is not necessary. The provision of the teacher-coach and the collaborative partners, as required in the situated learning model, provide interactivity in a far more authentic, and context-specific manner than is possible with pre-determined responses and feedback. Similarly, reinforcement that alternates affirming comments such as 'Well done', 'Excellent', and 'Good work' owes more to an 'instructivist' than a constructivist philosophy of learning. Such responses are unnecessary in a situated learning environment.

An important implication of the research is the need by designers to consider implementation as well as the design of the software itself (implementation by the lecturer in the classroom is considered in more detail in the next section). For example, if lecturers plan to group students, it is important for the designer to ensure that all activities and instructions be addressed to a group, not to an individual, which is frequently the case now (Alessi, 1996). Recommendations can be made on implementation conditions in introductory screens, *Read Me* files, or supporting documentation supplied with commercially produced software, where the designer can suggest to the lecturer or students using the product that it has been designed to be used in groups, where coaching is provided by the lecturer, where opportunities to articulate findings are provided, and so on.

Further implications relating to the design of multimedia include: an ecological interface is preferred by students who find navigation more intuitive than using buttons; students fear becoming lost in a labyrinth and therefore prefer a simple, referential system of navigation; and fewer, more complex and sustained authentic investigations of a resource are preferable to a large number of disconnected exercises or problems.

Implications for the implementation of interactive multimedia

The quality of instructional materials cannot be considered independently of the manner in which they are used. There are many advantages to be gained from implementing instructional materials of any form in a manner which creates collaborative learning environments and provides forms of scaffolding to support the construction of knowledge. The major implication for lecturers, students and university administrators is that multimedia materials are usefully designed and implemented socially, not exclusively as independent instruction for individual learners.

In order to promote collaborative learning with interactive multimedia, lecturers need to consider ways to maximise the opportunities for learners to collaborate. In times of scarce resources, this research vindicates the need to supply every student with a computer. Software used collaboratively in a situated learning environment does not require frequent keyboard and mouse use. Rather, the emphasis is on reflective responses that contribute to the creation of an authentic product such as a report, and where each participant provides a unique function or role to the task.

A further implication of the research is that the findings undermine the wisdom of the wholesale replacement of lectures and tutorials with individual interactive multimedia work. The inappropriate adoption of flexible modes of delivery, upon which such private work is predicated, may ultimately sacrifice effective learning for convenience.

As well as the support of other learners, students should also be provided with the support of the lecturer for a substantial period of time. It is advisable for lecturers to provide assistance to students as they use the program, not by supplying the solution if there is one, but by giving just enough guidance—the 'scaffolding'—to take them to the next stage. In such a manner , the lecturer can provide metacognitive support that, contrary to more 'instructivist' modes of instruction, can lead to higher-order thinking as students engage with the task.

Limitations of the study

The findings of this research provide strong support for an instructional design model based upon a situated learning framework for the design of interactive multimedia. However, three aspects of the study may have influenced the research in such a way as to reduce confidence in the findings.

The very positive response from the students in the study may be related to their reported history of university teaching and their very negative response to

'transmission' modes of teaching and learning. All the students reported that they were accustomed to such approaches, and that even when computer-based learning had been introduced into the teaching program, it had been in the spirit of the traditional lecture rather than as an innovative approach to learning. None of the students had extensive use of interactive multimedia before their use of the assessment program. The novelty value of the program may have played an undue part in the students' very positive reports of the interactive multimedia program and learning environment.

A second limitation is that the process of interviewing the students for the research after their use of the interactive multimedia program may, in itself, have facilitated reflection on the use of assessment strategies. This may have caused them to consciously synthesise their learning in much the same way that debriefing does, and heightened their appreciation of a variety of assessment strategies for use during teaching practice. The very act of the research interviews may in themselves have intervened positively in students' deeper learning of assessment and created a type of positive 'researcher effect' (Miles & Huberman, 1994).

The third limitation was addressed in Chapter 9, where the difficulty of assessing the students' transfer of knowledge to practice was attempted in a two-week professional practice period. Clearly, a longer period would enable a much more valid appreciation of whether students used the assessment strategies of their own volition, rather than on the direction of a supervising teacher, or as a result of a limited time frame.

None of these limitations impact directly on the situated learning model as an appropriate model of instructional design for interactive multimedia. Support for the model remains. However, the limitations do indicate scope for further research. These and other limitations are addressed within the context of recommendations for further research in the next section.

Recommendations for future research

The lack of generalisability of qualitative research is, at once, both its major weakness and its absolute strength. The inability to generalise is compensated to a great degree by the opportunity to study in depth a small number of students as they use a relatively new technology based on recent learning theory. Shank (1994) points out that it is sensible to open up the field of inquiry within instructional technology by focusing on an interpretive approach in the first instance: 'The most important reason to adopt new research methods is ... to open up new avenues and directions of enquiry, not close them down' (Shank, 1994, p. 349).

As described in Chapter 5, Salomon (1991) contends that research can be described as *analytic* or *systemic.* An analytic approach assumes that discrete variables can be isolated from their surroundings for study; the systemic approach assumes that elements are interdependent—the study of one may influence others to the extent that it is necessary to study the whole system. Salomon points out that: 'Because the two paradigms ... address different issues, yielding different kinds of knowledge, they ought to be seen as complementing and enriching each other, rather than ruling each other out' (p. 11). As Oliver and Reeves (1996) point out, 'systemic research, including in-depth case studies and long-term ethnographies, should precede analytical experiments aimed at determining the relative effectiveness [of one] approach over other instructional approaches' (p. 55).

The present research is indicative of the potential of such systemic research to open up new avenues of enquiry, both systemic and analytic. The findings presented here suggest many areas for further investigation and these have been tentatively listed in Table 10.1 below. The first column lists the topic of the present research which gives rise to further investigation, incorporating the situated learning model and all its elements, multimedia interface design, higher-order thinking and transfer. The second column gives a brief rationale for new research, or the limitation of the current research requiring confirmation of findings. The third and fourth columns give suggested research areas for systemic and analytic research.

Table 10.1:   Recommended systemic and analytic research

Aspect of research	Rationale or limitation	Systemic research	Analytic research
Situated learning model	The situated learning model comprised nine critical elements based, not upon a large research base, but on the review of literature.	Are all the critical elements of the situated learning model essential? Can the components be refined to a more succinct model?	Is a situated learning model appropriate for all learners or does it meet the needs of a particular type of student, e.g., self-regulated learners?
Authentic context	The context of the classroom was authentic to the students in the study because it was locally made. However, the context may not be authentic to other cultural groups.	To what extent does a culturally appropriate context affect learning in a situated learning environment? In what ways does perceived authenticity of context affect learning?	Is an authentic context in interactive multimedia representing a local culture more effective than one representing a foreign culture? How does the program compare with other IMM on the same subject but from a different cultural context?
Authentic activity	The activity used in the study was authentic but simulated. While meeting the requirements of an authentic activity as defined by Young (1993), Jonassen (1991b) and Bransford, Vye, Kinzer & Risko (1990), it lacked real-world involvement.	What are the critical elements of authenticity of task?	Is a simulated authentic activity as effective as a real-world task?
	The activity was assigned to students without choice. The Cognition and Technology Group at Vanderbilt (1990a) suggest that learning and transfer will be more effective if students generate their own problems rather than answer given problems.	Given a knowledge of the program, what types of problems of their own creation would students choose to investigate?	Are student-generated activities more effective in promoting learning and transfer than teacher-generated activities?
Multiple perspectives	Students were exposed to multiple perspectives both within the interactive multimedia program itself and from their partners' views. They were also required within the task to approach the problem from different perspectives.	Do multiple perspectives within an interactive multimedia program encourage students to formulate their own perspectives?	Is it more effective for students to use the same data base to complete two or three parallel large investigations as opposed to looking at different perspectives within a single activity?

Aspect of research	Rationale or limitation	Systemic research	Analytic research
Expert performances	Expert performances were provided in the interactive multimedia program in the form of short video demonstrations of assessment strategies which had been reenacted for the camera.	What do students learn from short video demonstrations? Can students experience 'legitimate peripheral participation' from video clips?	Are short video segments as effective as searchable videos of whole lessons filmed as they occur?
Collaboration	Support for collaboration as an important element in the situated learning model was strong in the current research. However, much of the instruction in flexible learning and distance education is based on individual work with students learning in isolation. An interesting finding in the research was the notion of collaboration 'by stealth' when opportunities were not provided legitimately.	What are the critical elements of collaboration, and how can they be accommodated in a distance learning program? Do students collaborate by stealth when they are expected to work in isolation on interactive multimedia program? On what aspects of the task e.g., procedural, path of action, metacognitive?	Is individual use of the interactive multimedia program on assessment without collaboration as effective as with collaboration, e.g., by distance students working in isolation?
Reflection	The findings suggest that an authentic context and an authentic task enable students to reflect without the need for external cues or reminders.	What are the critical factors enabling reflection in learning environments? Does the use of external cues and prompts within an interactive multimedia learning environment facilitate reflection?	Are external cues and prompts more effective in promoting reflection than an authentic task and context?
Articulation	Students were given the opportunity to articulate both within their collaborative groups and in their formal presentations. Distance education students would not readily have these opportunities.	What are the critical characteristics of articulation in learning environments? How might opportunities for articulation be incorporated in a distance learning package?	What kinds of articulation are important in facilitating learning, e.g., private and public, formal and informal?
Coaching and scaffolding	Coaching and scaffolding provided by the teacher was valued by the students in the study, although the majority of higher-order support was gained from their partners.	Under what conditions is coaching and scaffolding best provided by the teacher? When is it best provided by other students?	Is it necessary for the lecturer to be present for the entire period of use of the interactive multimedia program or at strategic times?

Aspect of research	Rationale or limitation	Systemic research	Analytic research
Authentic assessment	The students were assessed in a real-life, if simulated, context. Like the authentic task, it lacked real-world involvement.	How important is real-world involvement in authentic assessment?	Is authentic assessment more effective in a real situation, such as a presentation at a school staff meeting, as opposed to a simulated one?
	It was possible to provide effective authentic assessment within the learning environment (i.e., with lecturer support, public performances, etc.), but not totally within the software itself.	Is authentic assessment within interactive multimedia software achievable?	
Use of multimedia	Students using the assessment program based on situated learning devoted a substantial portion of their time to discussion and reflection rather than excessive attending to content.	Does the theoretical basis for the design of interactive multimedia influence the proportion of time spent by students on activities such as attending, reflecting, and discussing?	Do students spend a greater proportion of time attending to a linear multimedia format than they do to a complex, referential program? Do students spend a greater proportion of time discussing issues in a complex, referential multimedia program than a linear multimedia program?
Multimedia interface design	The main interface metaphor was a classroom which attempted to provide students with a cognitive device to enable information to be retrieved quickly and intuitively.	To what extent does the classroom interface contribute to the users' sense that their own construction of meaning is encouraged?	What effect does an ecological (metaphor) screen design as opposed to a lexical (words or buttons) design have on students' ease of navigation as they use multimedia?

Aspect of research	Rationale or limitation	Systemic research	Analytic research
Higher-order thinking	The students in the study were aware that they frequently postponed thinking to allow them to deal with difficult issues later—the strategy of 'cut and paste now, think later'.	What aspects of an interactive multimedia program facilitate direct thinking rather than procrastination or postponement of learning?	
	Students who did not know each other well appeared to use different types and proportions of thinking to the groups who had worked together before.	Does choice of partner and experience at collaboration facilitate higher-order thinking?	Do students use more higher-order thinking in groups of their own choosing?
	A high proportion of argument and challenge was found in two of the groups observed. One group appeared to use this process to enlighten the meaning they constructed, the other group did not.	What factors lead to the construction of meaning from multiple perspectives?	
	It was not within the scope of this study to examine whether a causal relationship exists between the use of higher-order thinking and students' use of assessment strategies in the classroom.	What factors within learning environments and students them-selves, such as the use of higher thinking, beliefs and attitudes, influence effective performance?	Does the use of higher-order thinking in learning influence performance?
Methodology of higher-order thinking classification scheme	The methodology used for analysis of higher-order thinking was the classification of talk from written transcripts using NUD•IST (Qualitative Solutions & Research, 1993) lacking contextual cues. Classification direct from video is now possible with *VideoSearch*(Knibb, 1997).		Does classification of categories from original video sources give higher inter-rater reliability than classification from written transcripts?
Transfer	While many models of transfer exist, it was difficult to find an appropriate model of transfer to use in the study. While transfer did appear to occur within the parameters given, many questions remain about the types of transfer and whether the effect is long-term.	What is an effective model of transfer for situated learning environments? When does learning transfer, e.g., when it is well known and has been incorporated deeply into the students' cognitive structures or when it has been taught in a situated learning environment? Or both?	Do students apply assessment strategies presented in the interactive multimedia program when working as fulltime teachers, e.g., in second year teaching? Is there long-term retention of assessment strategies?

Aspect of research	Rationale or limitation	Systemic research	Analytic research
Target audience	The assessment program was used with only one group of preservice teachers. However, it may be useful for other groups such as neophyte and experienced teachers.	What features of the multimedia program on assessment meet the needs of different target audiences?	Does the interactive multimedia program on assessment have the same outcomes with both prospective and experienced teachers?

These recommended areas for further research are issues that have directly emanated from the present study. They indicate a sample of the wealth of research that is needed if we are to begin to understand the processes that students use as they learn from multimedia programs, and the impact of the theoretical frameworks and models used in the design of those programs.

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APPENDIX 1

Style conventions used in the thesis

Style conventions used in the thesis

Spelling:

Spelling conforms with the Macquarie Dictionary (2nd ed.):

> The Macquarie Library (1991). *Macquarie dictionary* (2nd ed.). Australia: Macquarie University.

Referencing style

Referencing style, but not layout, conforms with the style presented by the American Psychological Association (APA), in keeping with the manual's differentiation between copy and final manuscript (p. 332).

> American Psychological Association (1994). *Publication manual of the American Psychological Association* (4th ed.). Washington, DC: Author.

Layout

Layout conforms to the accepted style for theses and dissertations of Edith Cowan University:

> Edith Cowan University (1994). *Thesis presentation: Notes to assist students in presenting a thesis for examination* (5th ed.). Perth: ECU.

Non-discriminatory language

Non-discriminatory language is used throughout the body of the thesis. Where possible, discriminatory quotations from other authors have been avoided or carefully selected to avoid discriminatory terms. When unavoidable (and this applies generally to material at least 15 years old) discriminatory terms of gender have been left in. Student transcripts have not been edited to remove any discriminatory language, although it must be noted that very little exists in their talk.

Throughout the thesis, a plural pronoun is frequently used with a singular noun. For example: *Each student described the use of assessment strategies relating to their own experience.* This has been done to avoid bias by exclusive use of the masculine *he,* or to avoid the sometimes cumbersome use of *his or her*, and *himself or herself.*

The adoption of this disagreement of noun and pronoun has been accepted in colloquial English for some time, and while considered ungrammatical, is gaining increased acceptance in written language with particular reference to the avoidance of gender bias, for example:

> Australian Government Publishing Service (1994). *Style manual for authors, editors and printers* (5th ed.). Canberra: Author.

Editing

Editing generally conforms to the *AGPS Style manual*. This includes hyphenation, which advises that some compound terms are hyphenated when used attributively, and not hyphenated when used predicatively, resulting in seemingly inconsistent hyphenation. For example: *'Problem-solving in the real world'* and '*Real-world problem solving*' are both written correctly according to the guidelines.

Australian Government Publishing Service (1994). *Style manual for authors, editors and printers* (5th ed.). Canberra: Author.

Terminology used to describe participants in the study:

Lecturer:	One who teaches a university course
Student:	A tertiary student in a teacher education course
Preservice teacher:	A tertiary student in a teacher education course
Child/children:	Student/s in a primary or secondary school
Supervising teacher:	A teacher in a primary or secondary school with responsibility for supervising a student's professional practice

APPENDIX 2

Record sheet for filming scenarios and interviews

Referenced: p. 99

No:

Name of strategy:

Name of teacher: _____ Year level _____

Name of school: _____ Date _____

Completed:

Filming of scenario in classroom ❏

Permission slips collected ❏

Relevant documents collected ❏

Interview with student/s ❏

Interview with teacher ❏

Filming of scenario in classroom

(Critical elements which need to be edited into final clip)

Notes

Questions to ask the teacher

Questions to ask the student

Progress sheet of compilation of
interactive multimedia program on assessment

Referenced: p. 117

The project half way through development; the grey shading indicates that the section was complete.

Assess-ment Type	Tech-nique	Item No.	Scene	Yr	Samples	Video scenario	Video teach-er	Video stud-ent	Inter-view	Reflec tions	Des cript ion	Given to Prog
Observing	Checklists	1	Teacher observing students and marking a checklist	1	Copy of recorded checklist	✔	✔	Not requir ed	David Clarke	✔	✔	1/3/96
	Anecdotal	2	Student doing problem. Teacher writing the record	7	Copy of anecdotal records	✔	✔	Not requir ed	David Clarke	✔	✔	1/3/96
Questioning	Higher order	16	Teacher asking how and why questions	10		✔	✔	✔		✔	✔	
	Factual	17	Teacher asking basic fact questions employing wait time	11		✔	✔	✔		✔	✔	
	Open-ended	19	Students working on good questions	7	Student work	✔	✔	✔	David Clarke	✔	✔	
Interviewing	Structured	14	Teacher doing a Newmann Error Analysis	8	Problem sheet	✔	✔	✔	Ken Clements			
	Open	15	Teacher interviewing student on under-standing of a concept	6/7		✔	✔	✔		✔	✔	
	Parent	25										
Testing	Diagnosis	23	Teacher using calculator to diagnose	6/7		✔	✔	✔				
	Performanc e-based	10	Students attempting a tangram activity	6/7		✔	✔	✔		✔	✔	
	Pencil and paper	8	Teacher discussing misconceptions	8	Copy of test	✔	✔	✔		✔	✔	
	Multiple choice	11							Ken Clements	✔	✔	
	Problem solving	9	Teacher developing a rubric with students	10	Copy of test	✔	✔	✔	Alan Scho-enfeld	✔	✔	
	Attitude	13	Teacher asks what do mathematicians do?	9	Students' pictures	✔	✔	✔				
Reporting	Oral	3	Student presenting an oral report to the class	11		✔	✔	✔	Paul Cobb	✔	✔	
	Written	4	Teacher giving advice on investigation	11	Copy of problem	✔	✔	✔	Paul Cobb			
	Portfolio	7	Leafing through student portfolio	6/7		✔	✔	✔	David Clarke			
	Investiga-tion	5	Marking an investigation	8	Copies of worksheets	✔	✔	✔	Max Stephens			
	Modelling	6	Teacher viewing modeling projects			✔	✔		Alan Bishop			
Self - Assessment	Journal	20	Teachers explaining how to write a journal	7	Journal entries	✔	✔	✔	Max Stephens	✔	✔	
	Reflective prompts	22	Teacher directing class to fill in lesson check	7	Lesson checks	✔	✔	✔	David Clarke	✔	✔	
	Self ques-tioning	21	Teacher explaining self-question checklist	7		✔	✔	✔				

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	Peer ass-essment	24	Teacher getting class to write own questions	6/7		✔	✔	✔		✔	✔	
		18, 13	Not to be used									

Research and lesson plans: Pilot study

Referenced: p. 132

Research plans

Pilot study

Date: Two weeks in May commencing week of Monday, 6 May.

Subjects: Two preservice teachers, studying mathematics method in the second year of their degree.

Week 1	Procedure	Resources and equipment
Lesson plan:	1. Lecturer introduces topic of assessment in mathematics education with following plan: • What does assessment mean in mathematics? • How were you assessed in mathematics when you were at school? • Introduce new approaches to assessment which suggest that a broader range of methods, which includes observation, interviews and other non-testing means, are appropriate. • Invitation to investigate the issues relating to assessment. (15 minutes)	❑ Room booked ❑ Guidelines for lecturer
	2. Introduction to the interactive multimedia package on assessment strategies in mathematics. • Demonstration of elements of the package and how they are accessed through the main classroom interface. • Demonstration of electronic notebook and how it works. • Demonstration of problem, and how the resource might be used to investigate an issue. Lecturer demonstrates and 'thinks aloud' as the resource is used. (15 minutes)	❑ Video camera, AC lead ❑ 90 min video cassette tapes x 2 ❑ Tripod ❑ Microphone ❑ 10 CD-ROMs of program ❑ 10 caddies for CDs ❑ 5 CD-ROM drives ❑ Extension cord ❑ Power board ❑ Note pad

	3.	Students are given a handout of brief instructions and how to get started on the program, and an investigation from the *Investigations* section to complete. Students work on the investigation for the remainder of the session.	☐ Handout of investigation ☐ Handout of brief instructions and getting started ☐ Statement of disclosure and permission slips
Week 2			
Lesson plan:	1.	Students continue to work on their investigations in the same manner as the previous week. (90 minutes)	☐ Video camera, AC lead ☐ 90 min video cassette tapes x 2 ☐ Tripod ☐ Microphone ☐ 10 CD-ROMS of program ☐ 10 caddies for CDs ☐ 5 CD-ROM drives ☐ Extension cord ☐ Power board
	2.	Students from 2-3 groups present their reports to the class. (15 minutes each = 45 minutes)	☐ Video equipment as above
	3.	Students who have been observed and videotaped are interviewed, using the interview schedule (45 minutes each)	☐ Tape recorder ☐ Spare batteries ☐ 90 minute audio cassettes x 2 ☐ Extension cord ☐ Interview schedules ☐ Note pad

APPENDIX 5

Guidelines for lecturer

Referenced: pp. 133, 145, 225

Guidelines for lecturer

There are at least three different roles a lecturer can assume in using an interactive multimedia program such as *Investigating Assessment Strategies in the Mathematics Classroom*. In tertiary education, lecturers often adopt a role of either *transmitter*, *manager* or *coach*. The characteristics of these roles are presented in Table 1 below.

Dimension of IMM	Teacher as ...		
	Transmitter	Manager	Coach
Teaching strategy	Teacher operates the IMM program projected at the front of the class while students watch	Teacher asks students to work with the IMM program individually in their own time	Teacher moves around class providing assistance as students work on IMM program
Teacher activity	Demonstrating, presenting information	Monitoring progress, record keeping, troubleshooting, removing impediments to progress,	Providing 'scaffolding', aiding students' inquiries
Students' cognitive activity	Listening, writing notes	Reading, completing activities	Reflecting, analysing, planning, problem-solving, collaborating
Potential learning outcomes	Memorisation of knowledge, factual recall	Knowledge, comprehension	Understanding, higher order learning, transfer

Table 1: Three roles of the teacher in the use of interactive multimedia

The role required in the present study is the role of the *coach*.

Guidelines for use of the interactive multimedia program

1. Be thoroughly familiar with the program and its possibilities.
2. Introduce the issue of assessment.
3. Provide brief instructions to students on the program elements and how to access them.
4. Model a problem briefly, by asking a question and thinking aloud as you demonstrate how you would go about investigating it.
5. Ensure students are working in groups of 2 or 3.
6. Be available to students at all times when they are using the program.
7. Respond to student's requests for assistance.
8. Initiate assistance by asking students frequently if they need any help, but do not impose.
9. Provide hints and ask questions.
10. Provide assistance to students as they use the program, not by supplying the solution if there is one, but by giving guidance—the 'scaffolding'—to take them to the next stage.

11. If a problem emerges which more than one group needs assistance with (such as a misconception about the required task or a problem with the program's operation), give this advice to the whole class.

Problems with the Assessment program revealed in the pilot study

Referenced: p. 142

Problems with the assessment program

- Some of the CDs did not allow students to highlight and select text.

- The program could not be accessed beyond a single default strategy if *256 colours* rather than *thousands of colours* was selected on the monitors control panel.

- Students could not save the *Notebook* and then open it again from within the program to continue writing notes, for example, from one session to the next.

- Students were not able to save the notebook directly after viewing a movie without it saving the file in the movie folder.

- It was not possible to select text across a page break in the filing cabinet documents.

- The digitising on one of the video clips (the *Portfolio* scenario showing a student's work portfolio) was much too bright and contrasty, and the images were almost unrecognisable.

- Some of the videos were very jerky when they first began to play. This was eliminated by pressing the start button of the controls rather than letting the video start by itself.

APPENDIX 7

Research and lesson plans:
Main study

Referenced: p. 144

Main study

Date: Three weeks in August commencing week of:
Monday, 12 August (Week 4 of semester)

Subjects: Six preservice teachers, studying mathematics method in the second year of their degree.

Week 1	Procedure	Resources and equipment
Lesson plan:	1. Lecturer introduces topic of assessment in mathematics education with following plan: • What does assessment mean in mathematics? • How were you assessed in mathematics when you were at school? • Introduce new approaches to assessment which suggest that a broader range of methods, which includes observation, interviews and other non-testing means, are appropriate. • Invitation to investigate the issues relating to assessment. (15 minutes)	☐ Room booked ☐ Guidelines for lecturer (x1)
	2. Introduction to the interactive multimedia package on assessment strategies in mathematics. • Demonstration of elements of the package and how they are accessed through the main classroom interface. • Demonstration of electronic notebook and how it works. • Demonstration of problem, and how the resource might be used to investigate an issue. Lecturer demonstrates and 'thinks aloud' as the resource is used. (5 minutes)	☐ Video camera, AC lead x 3 ☐ 45 min video cassette tapes x 9 ☐ Tripod x 3 ☐ Microphone x 3 ☐ 10 CD-ROMs of program ☐ 10 caddies for CDs ☐ Cassette recorder x 3 ☐ Spare batteries x 6 ☐ 90 minute audio cassettes x 6 ☐ Extension cord ☐ Power board ☐ Note pad ☐ 12 blank 1.4Mb disks ☐ Paper clips

	3.	Students are given their assessment details, together with a handout of brief instructions and how to get started on the program, and an investigation from the *Investigations* section to complete. Students work on the investigation for the remainder of the session.	☐ Statement of disclosure x 6 ☐ Handout of requirements for filming x 6 ☐ Handout of investigations x 20 (4 of each) ☐ Handout of brief instructions and getting started x 20 ☐ Handout of checklist of elements x 20 ☐ Handout of assessment details and evaluation forms x 30
Week 2			
Lesson plan:	1.	Students continue to work on their investigations in the same manner as the previous week. (Whole session)	☐ Video camera, AC lead x 3 ☐ 45 min video cassette tapes x 9 ☐ Tripod x 3 ☐ Microphone x 3 ☐ 10 CD-ROMs of program ☐ 10 caddies for CDs ☐ Cassette recorder x 3 ☐ Spare batteries x 6 ☐ 90 minute audio cassettes x 6 ☐ Extension cord ☐ Power board ☐ Note pad ☐ 12 blank 1.4Mb disks ☐ Paper clips

Week 3				
Lesson Plan	1.	Students from all groups present their reports to the class. Reports will be assessed as part of the requirements of the unit. Written report to be submitted one week later. (15-20 minutes each 150 minutes)	❐	Video camera, AC lead x 3
			❐	45 min video cassette tapes x 9
			❐	Tripod x 3
			❐	Microphone x 3
			❐	10 CD-ROMs of program
			❐	10 caddies for CDs
			❐	Cassette recorder x 3
			❐	Spare batteries x 6
			❐	90 minute audio cassettes x 6
			❐	Extension cord
			❐	Power board
			❐	Note pad
			❐	12 blank 1.4Mb disks
			❐	Paper clips
Interview plan	2.	Six students who have been observed and videotaped are interviewed by appointment, using the interview schedule. (45 minutes each)	❐	Cassette recorder
			❐	Spare batteries
			❐	90 minute audio cassettes x 6
			❐	Interview schedules x 6
			❐	Note pad

Statement of disclosure and informed consent for student participants

Referenced: pp. 144, 156

STATEMENT OF DISCLOSURE AND INFORMED CONSENT

Dear Student,

This letter is to inform you of the nature and purpose of the research I am completing as part of my PhD degree at Edith Cowan University. The study is an interpretive one entitled *Authentic learning in interactive multimedia environments*. The purpose of the study is to use the relatively new learning theory of situated learning as a framework for the design of interactive multimedia and to observe its effect. In order to do this, an interactive multimedia program has been produced on the issue of assessment. If you agree to take part in the study, you will be videotaped using the resource and I will be able to analyse the learning that takes place using qualitative research techniques.

There will be no discomfort to you, or any risks. You will use the program in your normal timetabled lectures, and I will interview you immediately after your use of the program, and then again several weeks later. Confidentiality is assured, and you will not be identified in any part of the research.

You will probably enjoy using the program and there are certain benefits both to you initially, and to the general teaching in the University and the effectiveness of the design of interactive multimedia programs. You will be using a program which has been designed with a great deal of care and combined expertise. It will provide you with access to teaching techniques and strategies employed by some of the best teachers in Western Australia. You will be able to reflect on how they assess students, and collaborate with your peers to investigate the resource, giving you ideas for your future classroom practice. Your participation in the research will also be extremely beneficial in the long term, in helping teachers to understand how people learn from interactive multimedia.

You need to be assured, however, that if you decide not to participate in the study, you will not be prejudiced in any way in the completion of your unit, and you are free to withdraw from the study at any time if you are concerned about any aspects of its conduct.

If you have any concerns about the project, you can direct them to me on # (Telephone), # (Fax) or # (Email). If you agree to take part in the research, please sign the consent form below.

Jan Herrington
Edith Cowan University

Consent form

I _____   (Name of participant)

 have read the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this research, *Authentic learning in interactive multimedia environments* realising I may withdraw at any time.

Signed_____

Date   _____

Guidelines for students being videotaped

Referenced: p. 144

Guidelines for students being videotaped using the interactive multimedia package on assessment

1. Please *speak out loud* as you use the program as I will be recording what you say to each other as you use the program. This will enable me to analyse how you use the interactive multimedia package and how effective the program is.

2. Try to *think aloud* as you move around. If a question comes into your head, please try to remember to speak about it to your partner. Even if you think it is clearly obvious what is happening, please say it aloud and describe what you are doing and why.

3. *Comment freely* about the program. I am interested in your negative comments as well as your positive ones.

4. If you have any questions about either the program or the task you have been set, *ask your lecturer*. Please do not ask me any questions during the videotaping of your use of the program.

5. Remember that *your identity will be anonymous* in the analysis of the data.

APPENDIX 10

Peer evaluation forms for student presentations

Referenced: p. 145

Peer evaluation forms for student presentations

Evaluation Form

Your name: _____
Group no. _____
Presenters' names: _____

_____

Criteria:	Score out of
✓ **Effectiveness of argument** How persuasive was the group's proposal? Were you convinced of the value of the suggestions?	___/5
✓ **Proposal's practicality** Were the suggestions practical and able to be implemented? How convinced were you that the suggestions would work?	___/5
✓ **Argument well supported** Was there sufficient evidence to support the proposal? Did you feel they had researched the problem well?	___/5
✓ **Presentation skills** How well did the group present the report? Did the presentation hold your attention?	___/5

APPENDIX 11

Research plan: Transfer study

Referenced: p. 147

Transfer study

Date: Four weeks in September/October commencing week of:
23 September

Subjects: Six preservice teacher, studying mathematics method in the second year of their degree.

Six supervising teachers in schools

	Procedure	Resources and equipment
Weeks 1 & 2		
Plan:	A list of six supervising teachers in schools was obtained from the Professional Practice Office. Each teacher was contacted at the school by telephone and advised of the study in the following manner: 1. Introduction, inform the teacher of the role of the researcher in the University and the nature of the PhD research. 2. Research was being conducted into interactive multimedia, and into how knowledge learned from programs transfers to teaching practice. 3. Ask teacher whether he or she is willing to answer a few questions about the professional practice student. Advise teacher that the student has been observed and interviewed in an earlier part of the research. 4. Assure teacher that the information disclosed would be entirely confidential and would not be used to assess the student's performance on his or her professional practice. 5. Ask if he or she would prefer visit to school answer questions over the telephone. (If the latter, ask for permission to tape on speaker telephone). 6. Consent form needed to be signed, and returned in reply-paid envelope. 7. Arrange time for interview.	☐ Appointment book ☐ Statement of disclosure x 6 ☐ Reply paid envelopes

Interview plan: Supervising teachers	Conduct interviews using the interview schedule for supervising teachers (15 minutes each)	☐ Interview schedule for supervising teachers ☐ Cassette recorder ☐ Speaker phone ☐ Spare batteries x 2 ☐ 90 minute audio cassettes x 2 ☐ Note pad, pen
Weeks 2 & 3		
Interview plan: Students	1. Arrange interview appointments. 2. Give students the first prediction sheet and ask them to comment on the actual situation on their teaching practice. 3. Give students the second prediction sheet with the list of factors supporting the outcome, and factors working against it. 4. Conduct interviews using the interview schedule for students and the list of assessment strategies featured in the interactive multimedia program on assessment.	☐ Cassette recorder ☐ Spare batteries ☐ 90 minute audio cassettes x 6 ☐ Interview schedules x 6 ☐ Prediction feedback form 1 x 6 ☐ Prediction feedback form 2 x 6 ☐ List of assessment strategies x 6 ☐ Book vouchers ☐ Note pad, pen

APPENDIX 12

Statement of disclosure and informed consent
for supervising teachers

Referenced: pp. 148, 156

STATEMENT OF DISCLOSURE AND INFORMED CONSENT

(Form to be given to supervising teachers in schools)

Dear

This letter is to inform you of the nature and purpose of the research I am completing as part of my PhD degree at Edith Cowan University.

The study is an interpretive one entitled Authentic learning in interactive multimedia environments. The purpose of the study is to use the relatively new learning theory of situated learning as a framework for the design of interactive multimedia and to observe its effect. In order to do this, an interactive multimedia program has been produced on the issue of assessment. Edith Cowan University students will be videotaped using the resource and I will analyse the learning that takes place using qualitative research techniques.

If you agree to take part in the research, there will be no discomfort to you, or any risks. I will interview you immediately after your supervision of the professional practice of one of the participants of the study, an Edith Cowan University student studying mathematics method. Confidentiality is assured, and you will not be identified in any part of the research.

Your participation in the research will be extremely beneficial in the long term, in helping teachers to understand how people learn from interactive multimedia.

If you have any concerns about the project, you can direct them to me on # (Telephone), # (Fax) or # (Email). If you agree to take part in the research, please sign the consent form below.

Jan Herrington

Edith Cowan University

-✂--

CONSENT FORM

I _____(Name of participant)

 have read the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this research, *Authentic learning in interactive multimedia environments* realising I may withdraw at any time.

Signed_____

Date   _____

Prediction technique form 1:
Assessment techniques

Referenced: pp. 151, 305

Prediction Feedback Form 1: Assessment Techniques

Name:

Prediction: (Made with August, 1996 data)

> In your mathematics classes on your teaching practice, you will use a variety of assessment techniques to assess student learning, other than pencil and paper tests.

Your description of the actual situation on your teaching practice:

There are probably many factors leading to the actual situation. The most important ones are:

A.	
B.	
C.	
D.	

.

Prediction technique form 2:
Assessment techniques

Referenced: pp. 151, 152, 306

Prediction Feedback Form 2: Assessment Techniques

Name:

Prediction: In your mathematics classes on your teaching practice, you will use a variety of assessment techniques to assess student learning, other than pencil and paper tests.

Factors which might have supported the prediction	Relevance	Brief explanation
Encouragement and support from supervising teacher.	☐ Not relevant ☐ Relevant, but not important ☐ Important factor	
Sufficient time to plan lessons carefully	☐ Not relevant ☐ Relevant, but not important ☐ Important factor	
Aware of other strategies from observing other teachers on professional practice	☐ Not relevant ☐ Relevant, but not important ☐ Important factor	
Aware of other strategies from using the multimedia program on assessment.	☐ Not relevant ☐ Relevant, but not important ☐ Important factor	
Aware of other strategies from the methods you experienced as a student yourself.	☐ Not relevant ☐ Relevant, but not important ☐ Important factor	

Factors which might have worked against the prediction	Relevance	Brief explanation
Supervising teacher dictated the type of assessment for each lesson.	☐ Not relevant ☐ Relevant, but not important ☐ Important factor	
Not aware of any other strategies that were appropriate.	☐ Not relevant ☐ Relevant, but not important ☐ Important factor	
Pencil & paper is best for grading purposes on teaching practice, because any other method is too difficult to follow up.	☐ Not relevant ☐ Relevant, but not important ☐ Important factor	
Not enough time to prepare a variety of assessment techniques.	☐ Not relevant ☐ Relevant, but not important ☐ Important factor	
There is no need for assessment of learning in classes taught during teaching practice.	☐ Not relevant ☐ Relevant, but not important ☐ Important factor	

Checklist of assessment strategies

Referenced: p. 152

Assessment Type	Technique	Scene
Observing	Checklists	Teacher observing students and marking a checklist
	Anecdotal	Student doing problem, teacher writing the record
Questioning	Higher order	Teacher asking how and why questions
	Factual	Teacher asking basic facts questions employing wait-time
	Open-ended	Teacher and students working on good questions
Interviewing	Structured	Teacher doing a Newmann Error Analysis
	Open	Teacher interviewing on understanding of a concept
	Parent	Teacher interviewing parent
Testing	Diagnosis	Teacher using calculator to diagnose
	Performance-based	Students attempting a tangram activity
	Pencil and paper	Teacher discussing student errors and misconceptions on a test
	Multiple choice	Teacher giving instructions for a test
	Problem solving	Teacher giving out a problem and developing a rubric with students
	Attitude	Teacher asks: what do mathematicians do?
Reporting	Oral	Student presenting an oral report to the class
	Written	Teacher giving advice on how to do an investigation
	Portfolio	Leafing through student portfolio of work
	Investigation	Marking an investigation
	Modelling	Teacher viewing students modelling projects
Self - Assessment	Journals	Teachers explaining how to write a journal
	Reflective prompts	Teacher directing class to fill in a lesson check
	Self questioning	Teacher going through a self-question checklist
	Peer assessment	Teacher getting students to write their own questions

APPENDIX 16

Peer review of research

Referenced: Table 5.10, p. 158

Peer review of research

The following publications and presentations enabled aspects of the thesis to be open to public scrutiny and comment during preparation:

Type of presentation	Aspect of thesis

Refereed journal publications

1. Oliver R. & Herrington, J. (1995). Developing effective hypermedia instructional material. *Australian Journal of Educational Technology,* 11(2), 8-22.

   • Elements of situated learning model

2. Herrington, J., & Herrington, A J. (in review). *Authentic assessment within multimedia.*

   • Literature review
   • Authentic assessment
   • Research findings authentic assessment

3. Herrington, A.J., Herrington, J., Sparrow, L., & Oliver, R. (in review). *Learning to teach and assess mathematics using multimedia: A teacher development project.*

   • Literature review
   • Situated learning model
   • Research findings: Transfer study

Refereed conference proceedings

1. Herrington, J. & Oliver, R. (1995). New learning theory and computer-based instruction: What situated learning tells us about the design of multimedia. In R. Oliver & M. Wild (Eds.), *Learning without limits: Vol. 1,* (pp. 177-186.). Perth: Educational Computing Association of Western Australia.

   • Literature review
   • Elements of situated learning model

2. Herrington, J. & Oliver, R. (1995). Critical characteristics of situated learning: Implications for the instructional design of multimedia. In J. Pearce & A. Ellis (Eds.). *Learning with technology* (pp. 253-262). Parkville, Vic: University of Melbourne.

   • Situated learning model

3. Herrington, J. & Oliver, R. (1995). Using authentic contexts and situations to improve the effectiveness of multimedia learning materials. In M. Wild (Ed.). *Selected proceedings of the West Australian Institute for Educational Research Annual Forum for 1995.* West Australian Institute for Educational Research (WAIER) Perth, http://www. cowan.edu.au/education/ waier_95/WAIERTOC. html

   • Elements of situated learning model
   • Literature review

4. Herrington, J. & Oliver, R. (1996). The effective use of interactive multimedia in education: Design and implementation issues. In C. McBeath & R. Atkinson (Eds.), *The learning superhighway: New world? New worries?* (pp. 169-176). Perth, WA: Promaco Conventions.

- Literature review
- Elements of situated learning model: coaching and collaboration

5. Herrington, A., Herrington, J., Sparrow, L., & Oliver, R. (1996). Student teachers learning to assess school mathematics. *Proceedings of the Apple University Consortium Conference*, [CD-ROM] Brisbane: AUC.

- Literature review
- Situated learning model
- Development of program

6. Herrington, A., Sparrow, L., Herrington, J., & Oliver, R. (1997). Investigating mathematics education using multimedia. In J. Willis, J.D. Price, S. McNeil, B. Robin, & D.A. Willis (Eds.), *Technology and Teacher Education Annual, 1997* (pp. 643-648). Charlottesville, VA: AACE.

- Literature review
- Situated learning model

7. Herrington, J., & Oliver, R. (1997). Avenues to understanding: A qualitative study into how students learn from multimedia. In T. Muldner & T.C. Reeves (Eds.), *Educational multimedia/hyper-media and telecommunications, 1997* (pp. 473-478). Charlottesville, VA: AACE.

- Pilot study findings

Non-refereed conference proceeding

1. Herrington, A.J., Herrington, J. & Oliver, R. (1996). Assessment in mathematics: A multimedia resource for preservice teachers. In J. Abbott & L. Willcoxson (Eds.),*Teaching and learning within and across disciplines* (pp. 65-71). Perth, WA: Murdoch University.

- Literature review
- Situated learning model
- Development of program

2. Oliver, R., Herrington, J., Herrington, A., & Sparrow, L., (1996). Using situated learning in the design of interactive multimedia-based learning environments. *Proceedings of the 12th Conference of the Japan Society for Educational Technology*. Japan: JET.

- Literature review
- Situated learning model

3. Oliver, R., Herrington, J., Herrington, A.J. & Sparrow, L. (1996). Developing an interactive multimedia package for tertiary teaching: Processes and issues. *Proceedings of the Higher Education Research and Development Society of Australasia Conference* (pp. 610-616). Perth: HERDSA

- Literature review
- Situated learning model
- Process of development of assessment program

4. Sparrow, L., Herrington, A.J., Herrington, J., & Oliver, R. (1996). Teaching strategies and assessment in mathematics: A multimedia resource for preservice teachers. *Short presentations for the 8th International Congress of Mathematical Education* (p. 669). Seville: ICME.

- Literature review
- Situated learning model

5. Standen, P., & Herrington, J. (1996). Multimedia simulations: A new use for technology in tertiary education. *Proceedings of the Higher Education Research and Development Society of Australasia Conference* (pp. 832-836). Perth: HERDSA

- Literature review
- Elements of situated learning model: authentic context

6. Herrington, A.J., Sparrow, L., & Herrington, J. (1997). The professional development of mathematics teachers: A multimedia approach. In Scott, N., & Hollingsworth, H. (Eds.), *Mathematics: Creating the future* (pp. 159-166). Melbourne: AAMT.

- Literature review
- Situated learning model
- Development of program

Conference or public presentation without publication

1. Herrington, J. (1995, May). *Course development and instructional design: An introduction to the issues and resources*. Presentation and workshop at the PAGE Consortium International Conference: Introduction to Flexible Learning. Perth.

- Literature review on situated learning (contrasted with systems approach)

2. Standen, P., & Herrington, J. (1995, November). *Multimedia for teaching introductory statistics: A functional approach*. Presentation to the Interactive Multimedia Users Group (IMMUG), Perth.

- Literature review

3. Standen, P., & Herrington, J. (1996, February). *A functional approach to teaching introductory statistics through multimedia: Uses of media in stimulating real world research*. Paper presented at the Teaching Learning Forum '96: Teaching and learning within and across disciplines, Perth.

- Literature review
- Situated learning model

4. Herrington, A.J., Sparrow, L., Herrington, J. & Oliver, R. (1996, April). *Exploring the mathematics classroom with multimedia*. Paper presented at the National Council of Teachers of Mathematics, 74th Annual Conference, San Diego, USA.

- Literature review
- Situated learning model
- Development of program

5. Sparrow, L., Herrington, A.J., Herrington, J., & Oliver, R. (1996, July). *Teaching strategies and assessment in mathematics: A multimedia resource for preservice teachers.* Paper presented at the 8th International Congress of Mathematical Education, Seville, Spain.

- Literature review
- Situated learning model
- Development of program

6. Herrington, A.J., Sparrow, L., Herrington, J., & Oliver, R. (1996, September). *The use of interactive multimedia in the teaching and assessing of mathematics.* Presentation to MASTEC Seminar, ECU.

- Situated learning model
- Process of development
- Early findings of pilot study

7. Sparrow, L., Herrington, A.J., Herrington, J., & Oliver, R. (1996, December). *Assessment and teaching strategies in Mathematics education: A multimedia resource.* Paper presented at Best Practice Showcase at Edith Cowan University, Perth, ECU.

- Literature review
- Situated learning model
- Development of program

8. Standen, P., & Herrington, J. (1996, December). *Uses of interactive multimedia microworlds in management education.* Paper presented at the Australia New Zealand Academy of Management (ANZAM) Conference, Wollongong, Victoria.

- Literature review
- Situated learning model: authentic context and authentic activity

9. Knibb, K., & Herrington, J. (1997, May). *Digital video analysis: A research tool.* Presentation to OFFER (Office for Educational Research) Seminar, ECU.

- Analysis of data on students' use of time using *VideoSearch*

Conference workshop presentations

1. Oliver, R., Herrington, J., & Stoney, S. (1997, June). *Developing interactive multimedia programs for higher education.* Ed-Media and Ed-Telecom 97: World Conference on Educational Multimedia and Hypermedia. Calgary, Alberta, Canada.

- Situated learning model
- Development of assessment program

Conference poster presentations

1. Herrington, J., Oliver, R., Herrington, A., & Sparrow, L. (1997, June). *Strategies and assessment in mathematics teaching: Multimedia resources for math-education courses.*
Ed-Media and Ed-Telecom 97: World Conference on Educational Multimedia and Hypermedia. Calgary, Alberta, Canada.

- Situated learning model

Computer software

1. Herrington, A.J., Sparrow, R.L., Herrington, J., & Oliver, R.G. (1997). *Investigating assessment strategies in mathematics classrooms* [Book and CD-ROM for Macintosh and PC]. Perth: MASTEC, Edith Cowan University.

   • Situated learning model

2. Herrington, A.J., Sparrow, R.L., Herrington, J., & Oliver, R.G. (1997). *Investigating teaching strategies in mathematics classrooms* [Book and CD-ROM for Macintosh and PC]. Perth: MASTEC, Edith Cowan University.

   • Situated learning model