# Learning through construction of interactive multimedia

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# Learning Through Construction of Interactive Multimedia

*A Thesis submitted in fulfilment of the requirements for the award of the degree:*

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*by*

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*Accompanied by the CD, "THE GARDEN©".*

## *Declaration*

Except where stated in the text, and in the list of acknowledgments, this thesis represents the original work of the author, and the material has not been submitted for the degree to any other university.

**Mrs Christine Anne Brown**

# *Summary*

This study examines the potential for the merger between computer mediated educational technology and the classroom, within the context of a constructivist philosophy. Parallel representations of the findings have been produced— a traditional text thesis, and a multimedia representation, *The Garden*, which accesses a CD also titled *THE GARDEN*, containing the full data set. Through a personal account of the teacher as researcher and designer in two class settings, with subjects at primary school and tertiary level, as students and student teachers, focused on the construction process or product development, the researcher demonstrates the benefits of learning through construction of interactive m ltimedia. This constructionist activity engages students for sustained periods of time, permits them to express their creativity and individuality, promotes higher order thinking and cognitive flexibility, and demands increased student reflection and communication of strategies.

A framework is presented to relate the activities of teaching and learning to interactive multimedia when the student occupies the role of software user, or software producer. For meaningful learning, students do not have to produce a 'product' aimed at a specific target audience. There are many benefits to be derived from allowing them to construct interactive multimedia using simple cognitive tools in a playful and grounded manner. This permits students to explore expression using multiple forms of representation and multiple representations. It also allows two different thinking styles— the bricoleur and the planner, to process learning materials in entirely different ways, even though the ultimate products may bear a striking resemblance.

Nine key study findings are presented, relating to constructivism/constructionism from the perspectives of teacher, researcher and designer, and the framework of interactive multimedia and teaching/learning. Implications are discussed for teachers, designers and researchers. Learners are challenged to develop a more self-regulated, lifelong approach to learning. The process focus on the construction of personal information systems permits the expert practice of sustained contact with an evolving body of knowledge. The product focus refines multimedia publishing skills. Standardised tests which maintain fixed curricula are seen as a major limit to the growth of social acceptance of the constructivist philosophy as a foundation for flexible education.

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# Chapter One - Study Context and Methodology

## Introduction

During the course of a PhD candidature, you run the gamut of Bloom's taxonomy and wear many hats—at times almost simultaneously. In keeping with the creative excitement of multiple perspectives, and in support of constructivist principles of evaluation which recommend multiple representations, the product of this study is an integrated package of print thesis and interactive multimedia CD.

One is not simply the electronic copy of the other. Thesis production is an avenue for the development of logical argument or narrative, which beg the revelation of puzzle pieces as if they were sequential in a non-branching trail. It is also an evaluation requirement.

In contrast, the CD, titled *THE GARDEN*, provides non-linear access to a wealth of primary and processed data, records the complexity of the entire research process in fine detail, and attempts to place viewers in the researcher's context. It is an additional component presented to examiners as primary data in the medium under investigation. The browser software constructed to link the viewer with the data is a HyperCard® program also titled *The Garden*, since it is the viewer's access to the resources of the CD.

The thesis and CD mark an endpoint and provide the researcher's answer to the fundamental research question— what is the impact of interactive multimedia construction tools upon the learning process ?

To identify the origin of this question, and establish the goals of the study, it is necessary to briefly turn back to its beginning. An individual's desire to conduct research stems from a force— a push or a pull. The decision to pursue a PhD study is very personal, and is influenced by background knowledge, life experiences, motivation and interest in a particular line of research. An undergraduate background in Veterinary Science, a quantitative Masters study in Veterinary Science, one semester of Pascal programming during a Dip Ed course, several years teaching secondary science, part-time work running university campus tours and advising students at career markets, and the experience of parenthood provided the researcher with background knowledge and experience for a new direction in education technology.

Motivation arose from the call in Education for the enhancement of problem-solving and higher-order thinking skills. These skills are required to tap a growing reservoir of readily accessed electronic information while finding solutions to real world problems. The student is expected to analyse a problem, seek out and select appropriate information, use that information to propose a solution then evaluate his/her performance. To achieve such a goal would require the development of considerable fluency in information technology, and a shift in the responsibility and roles of teacher and student.

After several years teaching secondary students science, it was disheartening for the researcher to watch the most creative and erudite students dismiss science as a subject in their senior years. The junior curriculum had changed to acknowledge process and technical skills, but the senior curriculum sat firmly with its content base. The underlying message that focus gave to the students was that "real" science didn't need process skills. Experience in Veterinary Science had indicated quite the contrary.

A further driving interest behind this study was the role of media in classroom learning. The use of still and video cameras in the junior and senior science labs captured events and prompted a different form of dialogue - one freed from straight text description of the scene to what was happening and why. Given access to video footage, students were keen to script a commentary; given paints and paper, they were able to design posters capturing the key issues in a topic. These techniques helped students "talk science" within the framework of everyday communication media which were rich in their representation of context.

From the classroom teacher's perspective, the coordination of these media was time-consuming so their use lacked spontaneity. Several benefits were anticipated for computer-orchestrated "multimedia", such as the ability to cater for a range of learning styles, the need to work collaboratively, if only due to machine shortage, and the diversity of skills required to produce multimedia materials. If students were to work with this form of media integration, it may well require cooperation among teachers at department if not whole school level. Any reduction in the barriers between staff in different subject areas within a high school was regarded by the researcher as a benefit to both teachers and learners.

As a natural extension of previous classroom activities with media, the researcher envisaged that students would want to produce and integrate resources themselves as part of the learning process. In a supportive environment, they had shown their natural desire to perform, to compete, to express themselves in different ways and to gain a sense of achievement from a real target audience.

The concept of student construction of interactive multimedia raised many questions:

- How was this technology developing?
- Could schools ever afford it?
- Would teachers find meaningful uses for the technology or was the technology driving the process?
- Was this another fad?
- Were reading and writing to fall by the wayside?

Conference proceedings from State and National conferences indicated that teacher emotions were polarised—as many teachers felt threatened as those who felt excited.

In the move from a high school environment to a university campus, the initial interest of the researcher was focused on student construction of interactive multimedia. For students to experience this process, the role of the teacher was vital. To study the relationship between learning and interactive multimedia construction for students, the researcher would have to create the learning environment as the teacher. This would enhance the relevance of the research findings for other teachers, through shared first-hand experience. However, it would also take considerable time to explore and understand instructional design theory and recent advances in learning theory, to develop appropriate interactive multimedia production and construction skills, and to learn how to incorporate computer-based information technology into the classroom through teaching experience. Student construction of interactive multimedia was not occurring in any classrooms accessible or known to the researcher in 1992, so the opportunity was not provided to witness this process and conduct case studies as a participant observer.

The study domain of learning and interactive multimedia construction was complex, ill-structured, ill-defined, and of equal relevance to the researcher and potential classroom students. As the study progressed through to construction of the interactive multimedia program *The Garden*, the researcher experienced a relationship between learning and interactive multimedia construction which directly impacted on the research process itself. In attempting to provide viewers with simple access to extensive, diverse information within a contextual structure, the researcher's construction of the interactive multimedia representation of the study, based on the metaphor of a garden, initiated a deep self-regulated learning cycle. Diligent recording, reflection, planning, organisation, analysis and re-structuring featured heavily. Unique interactive multimedia research tools evolved in the process, and subsequently shaped data collection, analysis and presentation.

## 1.1 Goals and Representations of the Study

The goals of this study are both interpretivist and developmental. Through a systematic personal account of the teacher as researcher, the study seeks to:

- identify the process outcomes of learning through construction of interactive multimedia from teacher, researcher, designer and student perspectives
- construct an integrating framework for these perspectives, and
- analyse the implications of these findings for learners

In reaching these goals, the thesis and CD emerged concurrently as different representations. The production processes in their contemporary evolution were more than complementary — they were synergistic, and deserve discussion. This chapter therefore provides two overviews which differ in magnification and related scope:

- Firstly, on low power objective, with the full study period in sight—a reflective time-based overview of the research methodology which uncovered the relationship between interactive multimedia construction and learning for the researcher.

- Secondly, on high power objective, with the classroom experiences in sight—a conceptual overview of the remaining chapters, which focus largely on students as learners constructing interactive multimedia.

These two views are bound by more than the structural relationship of a part to its whole. They share the process of interactive multimedia construction and explore in depth the role of interactive multimedia construction as a cognitive tool.

## 1.2 Low Power Objective— The Full Study Overview

The primary data set for this study is located on the CD THE GARDEN, and may be accessed via the HyperCard® program also titled *The Garden.* The integrity of the "PhD Walk" within the multimedia research landscape permits you to access all relevant data in its original format—text, image, sound, video or multimedia project.

*The Garden* has become a unique research tool, which continues to evolve in its appearance and functionality. A subset of text resources and processed data may be found in the appendices of this thesis. *Figure 1.1* on the following page shows briefly the content of the thesis chapters, the patterns of thesis and CD development, and identifies those chapters which discuss the nature and significance of the links between the simultaneous and synergistic production processes :

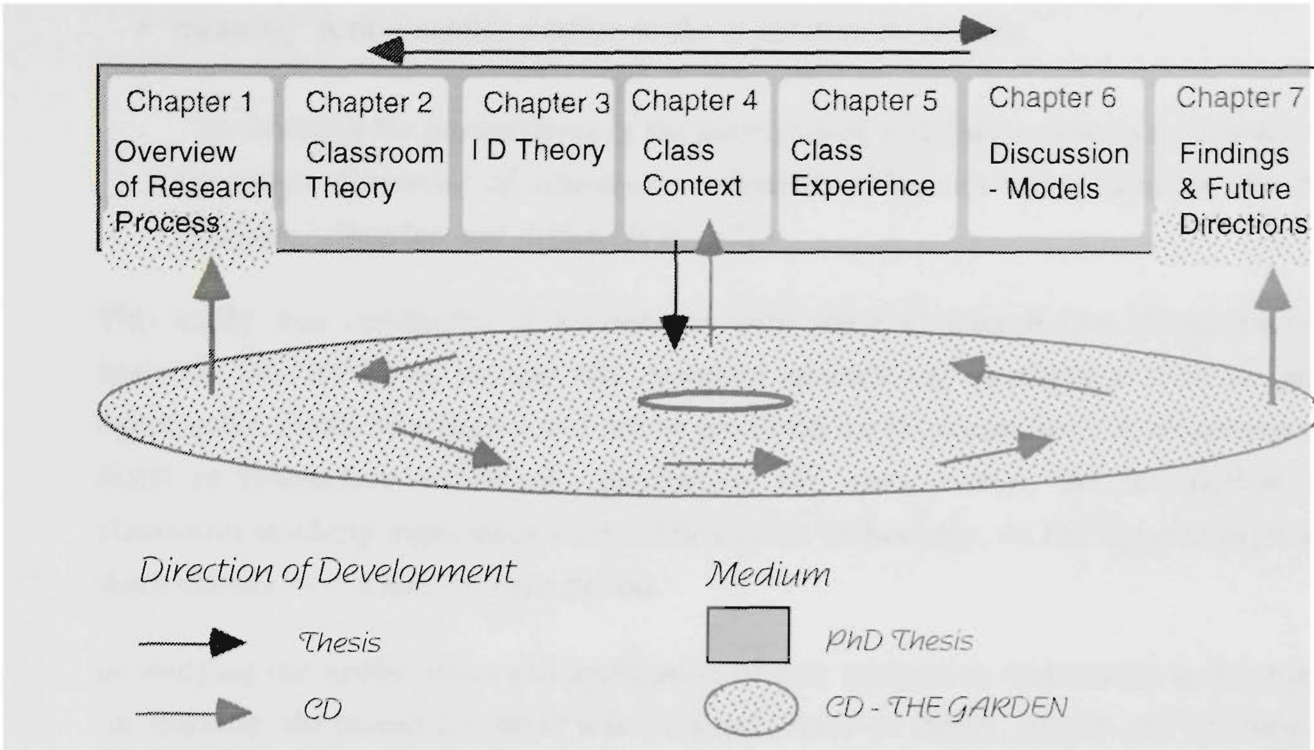


*Figure 1.1 : Relationship between thesis chapters and CD THE GARDEN*

Thesis and CD development were recursive, non-linear and interactive. The concepts presented graphically in *The Garden* were analysed and translated into a linear arrangement of chapters. As these chapters developed, *The Garden* was the tool used for data processing, pattern identification and construction of the full research context.

This time-based account of the research process conveys the evolutionary nature of thesis and CD development within a qualitative research environment. This was chosen by the researcher to accommodate flexible development and application of teaching strategies to support student construction of interactive multimedia in a new domain—the constructivist information technology classroom.

Bogdan and Biklen (1992) note five features of qualitative research:

- the natural setting is the direct source of data and the researcher is the key instrument
- qualitative research is descriptive, and nothing is considered trivial
- qualitative researchers are concerned with process rather than simply with outcomes or products

- qualitative researchers tend to analyse their data inductively— a picture takes shape as parts are collected and examined
- "meaning" is of essential concern to the qualitative researcher:

> *"by learning the perspectives of the participants, qualitative research illuminates the inner dynamics of situations— dynamics that are often invisible to the outsider." (Bogdan and Biklen, 1992, p32)*

This study was conducted in accordance with these characteristics of qualitative research. The following process was designed interactively in response to needs and opportunity. Fixed time lines could not be predicted for the researcher's development of skills in interactive multimedia production and construction, the acquisition of classroom teaching experience using information technology, or the opportunities to teach classes over a lengthy time period.

In studying the implications and application of new interactive multimedia technology for learning, the research context was a crucial source of theory, people and situations. Each of these factors influenced and moulded the study in a major way. Though they are discussed separately, they were entwined in reality.

## 1.3 Key Influences in the Study

### 1.3.1 Theory

Early reading centred on interactive multimedia as a new form of expression (Ambron, 1990), HyperCard® and its uses (Hooper, 1990; Koetke, 1990; Nicol, 1990), hypermedia as an information landscape (Florin, 1990), source of visual literacy (Liebhold, 1990) or cognitive load (Oren, 1990), and the developments the technology was making (Banathy, 1991; Barker, 1990; D'Ignazio, 1991; Dede, 1987; Gayeski, 1991). Without an understanding of the possible hardware solutions unfolding, it would not be feasible to anticipate what the student may face in the future.

For theory to guide software development, it would be necessary to make some calculated guesses. The information explosion rendered unlikely the possibility that teachers could easily re-process information for this medium, given the concurrent production and design skills they would need to acquire (Biros, 1990; Campbell and Hanlon, 1990). Perhaps this interim step wasn't necessary. Teachers may in fact be able to walk through this adjustment alongside their students. Though inspiring, the concept of teacher/student collaboration would require a philosophical shift in the teacher's approach (Bradsher, 1990; Hofmeister, 1990; Stebbins, 1990; Papert, 1991).

Learning theory and education technology were linked through the process of instructional design (Pirolli and Russell, 1990). While this term was appropriate for learning theory from the behaviourist and cognitive information processing perspectives, in which awareness of the type and structure of knowledge you wanted the students to acquire was a key factor, the associated principles and strategies were considered to contradict constructivist learning theory (Bednar, Cunningham, Duffy and Perry, 1991).

Constructivist epistemology would support the situation of cognition in a real world context (Brown, Collins and Duguid, 1989), the teaching method of cognitive apprenticeship, in which the teacher spontaneously modelled a problem solving process which included error handling, and the construction of multiple perspectives. A collaborative learning environment was ideal to permit learners to experience the rigorous process of developing and evaluating arguments to justify their different perspectives (Bednar et al, 1991).

The classroom environment was rich and complex, generated by learners, teachers and resources. Learners were seldom considered centre stage. Prime attention was focused on the curriculum and administration of an education system which regarded teachers as technicians:

> *"The technician-teacher is an abstraction. But this is the mold into which the system tries to force the teacher. ... It fits the conservatives' preferred mode of social organization.... And, of course, in the most local sense, it suits the school bureaucracy to define the teachers' job as carrying out a technically specified syllabus following a technically specified method." (Papert, 1991, p18).*

Constructivist principles focused on the individuality of the learner. The nature of the teacher's role would be different. It was necessary to take a closer look at a range of learner characteristics such as learning styles, learning strategies, collaboration, problem-solving, background knowledge and social skills. If learners were to become active knowledge producers, it was important to understand more about them in a holistic fashion.

The whole language approach to the classroom was one integrating framework which did place the learner in a central position :

> *"A basic tenet of whole language is that kids learn when they are in control of their learning and know that they are in control.... Whole language views learners as strong not weak, independent not dependent, active not passive. Learners are capable of learning relatively easily what is relevant and functional*

*for them. So the purpose of schools is to help learners to expand on what they know, to build on what they can do, to support them in identifying needs and interests and in coping with old and new experiences." (Goodman and Goodman, 1990, p226)*

The whole language approach discussed by Goodman and Goodman (1990) referred to the creation of Vygotsky's zones of proximal development (Vygotsky, 1978, p84) within the learners in the context of activities. Teachers were "insightful kid watchers" who supported learning without controlling it:

*"Whole-language teachers don't abdicate their authority or responsibility. But they lead by virtue of their greater experience, their knowledge, and their respect for their pupils. They know their pupils, monitor their learning, and provide support and resources as they are needed. They recognise that there must be collaboration between themselves and their pupils if an optimal learning atmosphere is to be created. Whole-language teachers believe that experiences and literacy events must be as authentic in the classroom as they are outside of it. Pupils must feel a sense of purpose, of choice, of utility, of participation, and of shared ownership in their classrooms and in what happens there." (Goodman and Goodman, 1990, p235)*

The role of the teacher was evolving, whether due to natural changes with age and experience, or the influence of external pressure. Developments in educational technology had been nudging the teacher from information disseminator to process facilitator (Smith and Westhoff, 1992). Change would not always be easy, and it would be equally important that both teacher and student transit in harmony.

The potential hidden assistant in the classroom was the educational software designer. Learning theory guided the software and resource materials they designed. If their learning philosophy was in harmony with the teacher, then a synergistic relationship could exist. At the other extreme, failure of an educational software designer to adopt and make explicit a theory of learning could lead to a mismatch between the intended use of their resources/software and the philosophy of the teacher. Students would not be the only losers in this situation— the teacher's experience with educational software would be negative, and the designer would gain no feedback as to the reasons behind software "failure".

Some designers geared the use of their software to a range of teaching philosophies and associated strategies. The Cognition and Technology Group at Vanderbilt (CTGV) produced the Jasper Woodbury Problem Solving Series, which illustrated an anchored approach to design, with problem solving opportunities afforded in a rich and complex context. Three potential teaching models were designed to accompany the program:

- model 1 - Basics First, Immediate Feedback, Direct Instruction - this was in direct contrast with the potential for anchored problem solving. All required subskills were taught first before students were allowed to solve any problems as a revision exercise.

- model 2 - Structured Problem Solving - this focused on minimising student error and confusion. Worksheets specified possible problem pathways to pursue.

- model 3 - The "Guided Generation" Model - emphasised the importance of generative activities by students, usually in groups, accompanied by the teacher as fellow learner. This was aimed at helping students to understand why it was important to learn various subskills and when they were useful.

Teachers were free to select a model in keeping with their teaching philosophy (Cognition and Technology Group at Vanderbilt, 1992).

Three key terms emerged from broad reading to provide a theoretical basis for this study— metacognition, interactive multimedia, and constructivism:

- metacognition - appeared in much of the education psychology literature on higher-order thinking, problem-solving and self-regulated learning. The concept was fuzzy—some regarded it as relevant only to the individual. Others acknowledged metacognition as a shared concept among people. The ability of a learner to set goals, plan, monitor progress, reflect, and adapt would certainly assist any complex construction process. Self-regulation was a highly worthy goal for any learner.

- multimedia - the term was usually used in literature in a generic sense to indicate two or more media. It could also be used as a shorthand version of "interactive multimedia", which suggested a direct alignment with computers. Developments in education technology were centred on the capacity of computers to orchestrate a range of media. The design basis for educational software unfolded the designer's theory of learning. The need for a learner to combine technical knowledge with creative expression in the construction of interactive multimedia was certainly a possible means of catering for and identifying a broader range of student abilities.

- constructivism - was an umbrella term to cluster not only a range of learning techniques but also a philosophy which could be applied within the classroom.

This term was controversial - with supporters and sceptics. It unfolded and juxtaposed the ideas of key theoreticians like Piaget, Vygotsky and Papert.

The interrelationship of these three terms formed the basis of the researcher's initial literature review. This review was presented at the Australian Society for Computers In Learning In Tertiary Education (ASCILITE) conference in December, 1992, and was subsequently published (Brown, Hedberg and Harper, 1994).

While definitions were expressed in decontextualised academic terms, they could be tossed around within a pool of theory, but would continue to lie beyond the reach of a practitioner. The interrelationships would remain hidden without people and context.

### 1.3.2 People

People provided not only the bridge to understanding, but also the motivation and reality. In this study, key people from several directions influenced the researcher. Supervisors and fellow researchers provided intellectual stimulus, challenged protocol and reasoning, and assisted with resources. Family members were the emotional and task-oriented anchors, and most vocal critics. Off-campus peer support came from associates met through workshops and conferences. A number of these associates became fellow members of project teams, and remained a vital support network.

On centre stage, however, were the potential learners— students, teachers, designers and researchers. Insight was introspective—gained from a reflective look within. The systematic recording of researcher insights was necessary to place them in their original context. Patterns of behaviour, skill development, knowledge and opinions were observed and requested from others. This was not limited to students in the eventual classes. Fellow students, teachers, researchers and family friends with varied understanding of the field of information technology all provided an array of questions, ideas and issues.

The personal reflections of the researcher were recorded to place data in context when the time came for reflection, analysis and synthesis of findings. Later it became apparent that some of this information was a vital piece of the puzzle for examiners— it would help to illuminate researcher bias, increase research rigour, and extend the potential target audience to fellow teachers.

### 1.3.3 Situation

The researcher's source of theory building during 1992 was access to physical resources—journals, books, conference proceedings and tapes, and people—

supervisors, other lecturers presenting theory in post-graduate courses, and fellow post-graduates. Concurrently, the researcher had the use of a powerful multimedia computer and the company of a highly competent programmer and laboratory manager. High calibre technical support was freely available. Theory and skill development proceeded together. Postgraduate classes were run in the computer laboratory next door, and offered peer support as well as the chance to observe learners in a multimedia classroom.

HyperCard® was the superglue used to construct a research diary, very imaginatively titled *PhD Diary*, in February, 1992. Daily entries were made in this diary to record activities and learn to express observations and events using new vocabulary. Over the course of the year, stimulated by involvement in a major project, *Investigating Lake Iluka*, considerable skills were developed in HyperCard® programming, instructional design, graphics and incorporation of media.

Under the advice of the Faculty Dean, PhD candidature was deferred in 1993 to lecture in information technology and science education for pre-service primary teachers. Lack of focus on the practical application of theory was the reason put forward. This provided the researcher with an invaluable "breather" to link the theory and skills developed in 1992 with natural teaching style in an exploratory way. Two images remain fixed—firstly the fearful faces of students confronted by computers in a compulsory Information Technology subject, and secondly, the delight and wonder expressed by science students seeing numerous images of the previous week's excursion to the steelworks in full colour on a computer screen before them.

Significant opportunities arose for the researcher to develop writing skills in the emerging genre of computer print support material, and multimedia presentation skills for lecture presentations and demonstrations. Also, as a member of the Interactive Multimedia Unit (as it was then known) within the Faculty of Education, the researcher was privileged to be involved as an instructor in an intensive 10 day client driven Multimedia Workshop. At the end of the workshop, the participants were extremely well versed in the content and ethos of the client. The construction process ensured that a knowledge structure was identified, then worked, re-worked, structured, constructed, analysed and both technically and creatively processed to present the software user with a message and offer them an experience. The learning experience for workshop *participants* was creative, motivating and helpful for the development of interpersonal and group skills.

The researcher continued to participate in a number of similar multimedia workshops—each time with more authoring skills and experience to share with participants. In many ways the collection of workshop experiences were the researcher's pilot studies. They provided strong support for the central focus of this research— the focus on the learner as multimedia designer.

By the beginning of 1994, the researcher had acquired sufficient knowledge of education technology theory, skills in interactive multimedia production and construction , experience teaching with computers , and evidence to support the study focus to begin the next stage of the study. This consisted of two classes which ran from March to November in 1994.

## 1.4 Classroom Experiences

Concern for the teacher *and* the learner was necessary to translate study implications into suggestions for implementation. One class known as EDUM (after the principal course code) focused on tertiary level pre-service primary teachers as the learners, regarding their need to both produce and teach with interactive multimedia. The other class known as G&T (the class was a group of gifted and talented children) focused on primary students who were able to produce interactive multimedia. Both classes ran for approximately twenty seven classes spread from March or April through to November, 1994.

Classes were not planned well in advance. The opportunities for the researcher to work with each class arose due to the researcher's interest in this area. Each opportunity was willingly accepted. The EDUM classes were elective subjects which may not have run without the presence of the researcher. The teacher of the gifted and talented class wanted to incorporate a computer based activity in the daily plan. She was looking for someone who could support children in creative computer activities other than word processing. The researcher had to design the classroom activities to suit the situation— a typical approach in schools.

As a *teacher*, the researcher designed initial class activities based on some pre-conceived ideas about the classes. These ideas were grounded in patterns of past teaching experience and led to the anticipation of certain similarities and differences between the primary and tertiary classes.

As a *researcher* it was necessary to identify these potential biases. Researcher perceptions of class similarities and differences would be accompanied by certain assumptions about their possible impact on classes. The following anticipated similarities and differences between the EDUM and G&T classes were part of researcher bias. They reflected a mapping of the researcher's repertoire of classroom management and learning strategies onto the classes.

### 1.4.1 Anticipated Similarities Between EDUM and G&T Classes

#### Teacher/Researcher/Designer Perspective

In both classes the researcher would be the principal teacher. On the positive side this would enable teacher insights, reasoning, planning, organisation and processing to be shared. It was hoped this would increase the relevance of the study for other teachers. The teacher reflections would enable formative evaluation of class proceedings and ensure classes were responsive to ongoing change. They would not be run to a rigid, pre-determined format with summative evaluation. On the negative side, the cognitive load required to support a class could reduce the capacity of the teacher to note extensive observations on students, but may not necessarily compromise observation quality and poignancy.

The design experience of project work should enable the teacher to relate to the design process students would experience, to share strategies and appreciate difficulties, to design support tools for classes, and to assist with organisation and programming needs. Additional help would be available for either teaching, supervision, small group work or technical support. The aim would not be to see what one "miracle teacher" could achieve, but what the students could achieve given the most supportive environment possible.

#### Constructivist Philosophy

The teacher would adopt a constructivist approach to the learning environment. Students would select projects of their own interest, work in different groups of varying sizes, peer tutor, reflect on process and present work to the class. The structure or style of production work would not be determined by the teacher beyond basic skill level. An explicit aim of the study would be to observe the process of student production when they were free to pursue their own interests.

#### Group Work

Personal experience of interactive multimedia construction through project work with teams within and beyond the University of Wollongong had provided the researcher with considerable insight. Some of the key variables across projects related to the rapidity of prototyping in the development process, the skill level and experience of the team, the role of team manager, resource organisation and version control, the purpose of the product, and the personal motives for team involvement. Communication was crucial, but consensus was not always required. Creative tension was maintained by strong leadership but certainly not control. It was a creative process, and team members had to make their own choice to engage in it.

Given this less than exhaustive list of variables, it was anticipated that group composition would exert considerable influence on the satisfaction and functioning of student groups in both classes.

### 1.4.2 Anticipated Differences Between EDUM and G&T Classes

#### Pre-service Teachers and Primary level Students

Advances in technology were the norm for primary school students well versed in a barrage of computer or video games. Pre-service primary teachers were introduced to information technology the previous year, and were facing a double agenda of learner and teacher. It was anticipated the two classes may reveal some interesting patterns regarding ease of use, creative freedom and pressure of expectations of peers.

#### Outcome-driven and Open Curriculum

The double agenda of teacher/learner for the EDUM students would require systematic skilling in multimedia production, theory on instructional design, focus on several multimedia products, the use of a range of applications, written work and presentations for the purpose of outcome-driven evaluation.

The G&T class of twenty two students was drawn from nine local primary schools and met one day per week for extension work. The specialist class teacher was responsible for establishing profiles on the students for report purposes. These students would be given creative freedom, supported with media digitising, and not subjected to overt evaluation on any computer-based product.

It was anticipated the direct feedback of marks and the drive of the evaluation system would place considerably more pressure on the EDUM students to focus on external motivation.

### 1.4.3 The Nature of Primary Data

The researcher's electronic *PhD Diary*, begun in February, 1992 was continued throughout the study. All activities were noted in this one HyperCard® document, with a separate screen for each day. Weekly class reports were written for the first semester EDUM course—EDUM 221. Once the G&T class began, the researcher developed a performance support structure to facilitate consistent data recording, as both classes were conducted on a Thursday. Two parallel HyperCard® stacks were used to prompt the recording or collating of data on equipment, attendance, process and follow-up for the G&T class and EDUM 212. Most of this information was derived from researcher notes in *PhD Diary*.

The video camera and tape recorder were used in many classes, providing considerable footage of class activity. The video camera was usually mounted on a tripod. Occasionally the camera was manually operated, by either the researcher or the students. Formal student recording sessions for multimedia resource production were run according to student needs. All student presentation lessons were video recorded to allow the researcher to focus on the students and their work— to share the experience and provide feedback, free from the concern of noting events. This also formalised the occasion, and gave the students the sense of a larger target audience. These "Show and Tell" sessions were very popular.

Student work in various stages was retained to reflect on the production process. This collection was comprised of a range of video, audio, text, graphic and multimedia snippets. Coupled with this was the collection of teacher-generated software tools for demonstration and student use.

## 1.5 The Development of Unique Multimedia Tools for Data Processing

Initial data analysis focused on the extensive *PhD Diary*, which stored the complete collection of text data in a form which was chronologically and contextually accurate. Text was exported from the HyperCard® stack, formatted in a word processor and printed out for first pass analysis.

### 1.5.1 Theme Identification from the Narrative Diary

Diary notes were written in a range of styles, reflecting both minor fluctuations in mood, and major changes in the nature and extensiveness of a blend of personal and research information, objective and emotional material. Initially the diary functioned as an event, idea and technique recorder, but became an emotional outlet, a place to reflect, a planning and self-monitoring device and a means of practising expression. Ideas were not lost through recording failure. Ideas could be ignored through failure to re-access them.

As with any eclectic collection, it was readily apparent that there were key themes within the lengthy document. It must be stressed that theme identification was a reflective process. Themes did not drive the data collection process— they emerged from the data. The following major themes were identified in *PhD Diary* mid way through 1994:

- theory / literature
- presentations
- major projects
- research process
- G&T class
- EDUM class
- software tools

This triggered the first adaptation to *PhD Diary*. Seven new fields with the above titles were added to the diary stack. This allowed the researcher after reflection and analysis to copy and paste notes into relevant theme fields. The same text could appear in as many theme fields as the researcher considered appropriate. Data interpretation could be repeated a number of times to ensure consistent theme coding. The chronological structure of the general notes field was the most natural mechanism for data recording. Ideas could flow in freely without concern for their ultimate destination, and the context surrounding a theme note could always be established by viewing the complete diary entry for the day. The time consuming process of note selection for themes meant the landscape of notes was crossed many times. Sometimes all themes were identified and processed in the one notes field and at other times, one theme only was pursued and isolated from notes for several months.

Once notes were in themes, each specific theme field plus the date field was exported to produce theme documents. Very soon, the process of theme identification also began within these documents. To simplify stack structure and maintain thematic integrity, sub-theme headings were then entered in the theme fields of *PhD Diary*.

### 1.5.2 Choice of Integrating Metaphor for the Study

The diary themes identified in the period from 1992 to 1994 encompassed all aspects of the researcher's work. No distinction was made between class data and personal researcher involvement with any aspect of educational technology. The complex and ill-structured nature of the personal account required rigorous and consistent data collection, in order to assist in the grounded identification of patterns or key issues. The researcher assumed that the classes would feature prominently in the mandatory traditional thesis, but the full research context was required to identify more subtle contextual issues.

All multimedia data was collected, archived, and its details recorded in *PhD Diary*. Several episodes over the two year period of research to date had indicated multimedia construction was a powerful tool to monitor, orchestrate, structure and present research findings. Firstly, for archival purposes, the researcher compiled work completed during 1992. This was a powerful mechanism to appraise the depth and scope of the researcher's conceptual growth and skill development— it presented the "big picture" of the research landscape at that stage. Secondly, the researcher noted a marked discrepancy between the positive audience response to the interactive multimedia presentation and the indifferent feedback on the conference paper at the ASCILITE conference in December, 1992. The interactive multimedia presentation was a powerful visual aid to complement the verbal presentation, and enabled the researcher to present quite complex material in relatively simple terms.

When the potential arose to press a CD version of the study, the full multimedia scope of the research context could be conveyed. Major project involvement had helped the researcher to develop production and design skills in a range of teams, and had promoted the development of problem-solving skills in the knowledge domain under study. Presentations had helped to focus the researcher on the task of communicating key concepts to peers. Identification and presentation of key concepts was a powerful learning experience. This collection of presentations indicated the researcher's conceptual evolution during the period of the study.

The research context could be presented as a unique multimedia landscape, whose features reflected the key themes of the study. This representation would complement, not parrot the thesis. The ultimate expression of this idea—*The Garden*, would develop as a processfolio, not a product for publishing. Its development would be aligned to the needs and thinking processes of the researcher. Such needs and thinking processes would prompt the development of a series of powerful research tools, to further validate the contribution of interactive multimedia construction to the research process itself. The following account traces the development of *The Garden*.

The first attempt at conceptual integration of the study was on Christmas Eve, 1994. It stemmed from a self-directed question about good places to think—the garden was a personal favourite. The concept grew— a tree with 14 branches for one class study and a vine with 22 flowers for the other; a pathway through the garden to indicate the passage of time, flowers along the pathway representing the presentations.

Where was the researcher in the garden scene? The researcher was the gardener. Was this appropriate? Many tasks of a gardener were listed, and parallels were drawn with a classroom teacher. The gardener had to contend with many variables in a garden of 30 plant species, but this was no more complex than a teacher's classroom domain with 30 students. People accepted the complexity of a gardener's role, assuming there were variables over which the gardener had no control. The gardener metaphor was an opportunity to intuitively convey the complexities of a teacher's role.

The garden metaphor was certainly not new, but it was creatively stimulating in the circumstances. If the garden as a living system had inputs, processes and outputs, what were the metaphoric equivalents? Inputs of sunlight, soil and water were equated with teaching philosophy, theory and resources. Sunlight provided the tone of the garden, theory could reside in a theory pool rich with minerals from weathered pebbles, and resources for the garden could be scattered via a sprinkler. Outputs from the garden were plant growth and the creatures which fed in the garden. The flowers along the path were short, showy presentations made by the gardener. The large tree and flower bed (graphically better than the vine with flowers) housed student output. Major projects were viewed as birds in the garden. Having stopped for a feed, they had the capacity to take off on their own. The gardener provided natural roles for the researcher. "Teacher" tools would reside in the toolshed. Knowledge of gardening processes would be stored in the gardener's diary.

The core screen of the global garden scene, the "PhD Walk", shown in *Figure 1.2*, took time to establish. Major research objects — the classes, toolshed, theory pool, and gardener's diary, were represented first. Of these objects, only the classes were accurately placed according to the year posts along the pathway.

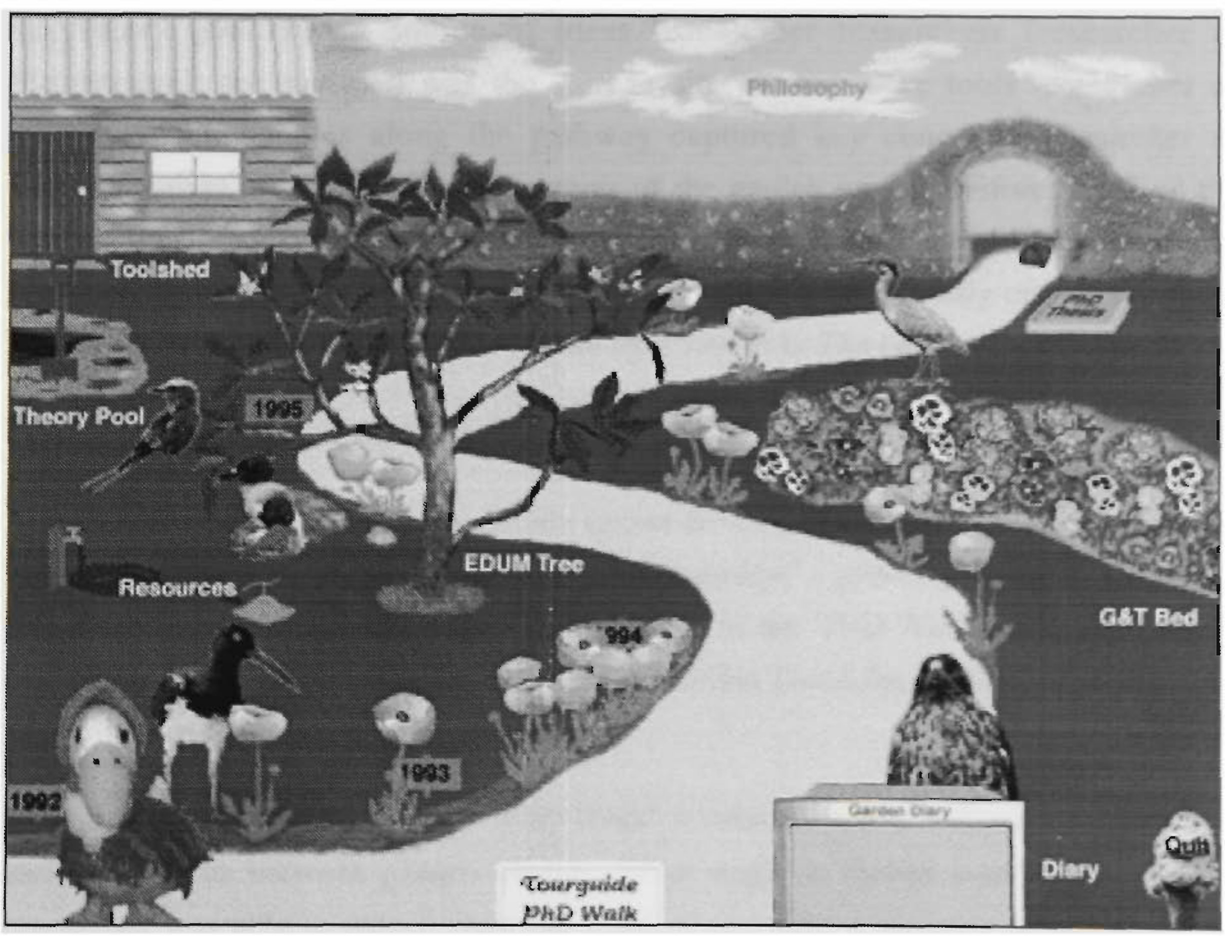


*Figure 1.2 : "PhD Walk" from The Garden*

The other objects spanned the full study, and were placed according to researcher preference for graphic dominance. Project work (birds) and presentations (poppies) were incorporated within accurate time frames.

There were many versions of the garden image. As the researcher struggled to develop a graphic style, this provided valuable, intensely absorbing thinking time. Visual representations of time-specific themes could be dragged around within their narrow graphic time zone to create the best aesthetic, but ultimately, the clutter of 1994 was an accurate representations of the time period of most intense and diverse researcher activity.

The aim of this key graphic was to present a holistic view of the PhD study, so any aspect of the work would be viewed in the context of its relationship to the other parts. If viewed in sequence, the birds showed the design and production experience of the researcher as a project team member.

Each object presented its own perspective of the garden, and was of intense interest to the researcher at different times. The classes demonstrated the blossoming of student work (researcher as teacher); the diary was a reflective journal (researcher as learner); the theory pool was a source of ideas from other researchers (researcher as theoretician); the toolshed was the storage site for cognitive tools (researcher as designer); the poppies along the pathway captured key concepts (researcher as communicator). The multiple perspectives of the garden were therefore based on the various functional roles of the "gardener". The origin of numerous skills and ideas of the researcher could not be represented in a non-linear manner easily or concisely in a text thesis, but could be browsed at leisure by a viewer in *The Garden*.

### 1.5.3 Relationships among Content, Objects and Information Access

The sub-structure of each major garden object developed over time in response to the nature of the data collected— this was "reverse design" - grounded in data. The seven themes of the diary each had a graphic equivalent in the "PhD Walk". Instead of words to indicate theme selection in the diary, the researcher found the graphic representations of the themes more intuitive.

Development of the palette in the "PhD Walk" involved a global analysis of similarities and differences between garden objects. What might a viewer want to know? The researcher was able to detach from the material and take a viewer's perspective. The viewer could find out the nature of the object in overview fashion, the theory related to that object, the researcher's diary notes about that object (who, what, why, where, when or how in fine detail) or the nature of the object in more detail (view the collection of resources).

Five major theory themes were identified which encompassed the main garden objects:

- classroom theory— accessed from either class
- instructional design theory— accessed from any project bird except *The Garden* bird
- theory about software tools— accessed from the toolshed or the resource sprinkler
- theory about theory itself— accessed from the theory pool
- deeper philosophical issues about research and learning— accessed from the gardener's diary and *The Garden* bird

These themes were colour coded, to allow any viewer to pursue researcher coded lines of theory, so five colours of theme "pebbles" appeared around the theory pool. A viewer could access the theory related to the object of interest, or could browse the complete theory pool and access concepts of particular interest across themes.

Diary notes for each object linked directly to the diary theme, to allow the viewer to read associated researcher notes. The full context of the notes could be established by selection to view the "Full Diary Entry".

Each key area within *The Garden* has been graphically represented in the final section of this thesis, titled "Maps of *The Garden*". A brief description of the rationale behind the researcher's screen design accompanies each graphic. *The Garden* was developed as a research tool and processfolio, not a product for publishing, so its developing structure was aligned with researcher needs and thinking processes. As conceptual links between garden objects became clearer, navigation was simplified. The assimilation of new material was followed by design changes which illustrated the process of accommodation.

Researcher awareness of potential viewers facilitated detachment and stimulated the development of data structures. How might a viewer such as a teacher wish to see the data? In the classes, the teacher notes had been recorded. What if the viewer wanted to follow the profiles of a number of students and look for their own patterns? What if the viewer wanted to hear student comments or ideas? The multimedia construction process thus drove data processing structures in directions which may not have been otherwise pursued. Components of *The Garden* grew in response to a need as it was identified. Student profiles could, if compiled, contain numerous media snippets over the twenty seven week period—a chance for the researcher to review the data and almost 'relive' the class. The sprinkler provided a structure for comparison of classes, through access to the media collected and produced by each group.

## 1.6 Research Functions of the Multimedia Construction Process

While *The Garden* was initially conceived to integrate and publish the multimedia version of the study alongside the thesis, as a publishing statement and demonstration of skill development, the advantages of this powerful construction process as a learning tool for the researcher pushed its development in other directions.

For the researcher, the multimedia construction process:

- clarified and unfolded a structure for the data collected during the study - it represented the researcher's developing mental model
- facilitated access to class material to analyse findings and make comparisons. Rapid juxtaposition of material assisted pattern identification.
- allowed focus on an aspect of the study while maintaining awareness of its overall context. This permitted the researcher to view the study from a range of perspectives.
- provided a structure for the presentation of primary data as well as data at different levels of processing. This increased the researcher's ability to expose researcher bias.
- enabled the evaluation of this study from a constructivist perspective— since the integrated output of thesis and CD would provide the viewer with access to context, process and logical argument as evidence of learning.
- prompted the development of unique multimedia tools to facilitate rigorous data collection, processing, organisation and re-organisation. Such ease of manipulation and tailored display of qualitative research data would not have been possible without these tools.
- allowed the forces of creativity and analysis to balance each other.

## 1.7 Synergy in Parallel Development of CD and Thesis

This thesis and *The Garden* developed alongside each other, and interacted frequently, once the garden metaphor was established and the pieces of the "bigger picture" were clearer. The diary notes now residing in a garden context continued to monitor process and provide the stability of a reference point in this self-regulated creative process. The gardener's diary was the place to go and reflect, pour out feelings, plan development, comment on progress and note technical production details for future reference. The discipline of recording daily events was wonderful for developing memory, noting detail, and describing a range of situations. Many diary notes made their way into this thesis.

The development of the philosophy section was a rich experience. A visit to this part of the garden had the capacity to alter mood, and regain the deeper purpose of the study. There seemed no parallel place for such quotes in a text document unless the screens were printed in full colour.

While software tools could be anchored to tools in the toolshed in accordance with the metaphor of teacher as gardener, recorded in the inventory, it soon became apparent that these software templates could be attached to many gardener tools in the toolshed. Their application was only limited by the creativity of the teacher or student using them.

Excitement accompanied the realisation that simultaneous thesis and multimedia production was providing an interface between theory and practice. Following periods of intense abstract writing, there was often a tug to play with graphics, and many design problems were solved directly in the graphics mode. With a concrete image it was easy to flip between roles of producer and viewer. Visual solutions didn't always require a label, as they automatically stood in a rich spacial context. Intuition was a more common ally in design than logic.

The flow of logic in the thesis required several re-shuffles to set key concepts in a broad perspective. *The Garden* stimulated a desire to frame all events within the broader context. Thus a parallel in the thesis would see the classes set within the broadest framework of multimedia, teaching and learning.

## 1.8 The CD — THE GARDEN

The "Maps of the Garden"— the final appendix of this thesis, illustrate the key areas of multimedia access to *The Garden,* and describe their focus and functionality. An exploration of this multimedia landscape on the CD provides you with access to the full data set. It illustrates the research context, provides process notes in the Garden Diary, presents notes and thoughts of teacher and students in the classes, conference or public presentations given by the researcher, software tools authored for classes or projects, and examples of major projects with which the researcher was involved. This is the researcher's personal information system, which has been designed as part of a learning process, and doubles as a processfolio. It is not simply a kiosk for simple access to qualitative data, though that was an early aim of its development. Research tools are embedded in the landscape. Beneath the surface lies a very large amount of material. If a viewer was interested, it would take several days to view all attached material. The version you have on the CD will already be outdated. As the researcher moves into a new phase of work, other aspects of *The Garden* will emerge, and other data analysis and presentation tools will continue to develop.

## 1.9 High Power Objective— The Thesis Structure

The following chapters synthesise in text what is represented in multimedia format in *The Garden.* Constructed with hindsight, this perspective is less bound to context and time than the CD.

The theoretical focus which emerged early in the study— metacognition, constructivism and interactive multimedia, became camouflaged in the study goals, which sought to identify some of the process outcomes of learning through interactive multimedia construction, and accompany these with perspectives of the teacher, designer and student in a constructivist information technology classroom. The practical emphasis was placed on process, higher-order thinking, information processing skills and problem-solving skills of a self-regulated learner, who must meet the workforce demands of flexibility. The original focus of the researcher— student construction of interactive multimedia— remained the central activity in each class. It was hoped the developing rapport between the students and teacher would uncover vital student perceptions of the learning processes associated with construction of interactive multimedia.

Thesis format should be designed to tell a logical story. In this case it is based on a qualitative experience which was not driven by pre-specified data collection or methodology. Literature review and analysis were not aimed at selection and justification of methodology to extend past research. Literature review and analysis were used to build a conceptual framework for the study goals.

The baseline or point of reference was the constructivist classroom (Chapter Two). The influence of educational software designers on this environment was analysed and presented as a series of scenarios which varied due to the designer's desire for control (Chapter Three). Classes were anchored in this theoretical context (Chapter Four), and data analysis (Chapter Five) led to the next stage of model development (Chapter Six). A second wave of literature was reviewed to compare study findings with the findings of other researchers, prior to the statement of research implications (Chapter Seven).

The key issues of each chapter are outlined in slightly more detail below:

*Chapter Two* - The Typical Classroom Environment. A baseline for comparison. Framed by the current goals for education, the typical classroom environment is discussed from the perspectives of a range of highly variable factors. Highlighted are the special interpersonal and intrapersonal qualities developed by the teacher, and the range of characteristics the learner brings to the environment. Curriculum and evaluation are seen as key constraints on effective classroom practice.

*Chapter Three* - The Addition of Computer-Mediated Technology. Discussion focus moves to an individual whose presence is felt but seldom seen in the technology classroom—the educational software designer. Learning theory exerts a tremendous influence on software design. The relationship between the designer and the classroom teacher provides a basis for analysing the style, functionality, and direction of development of educational software.

*Chapter Four* - The Classroom Context. The people on centre stage in this study—the students, are placed in context alongside teachers and educational software designers. This occurs in two classes. The context, background, resources and anticipated process outcomes of each class are described.

*Chapter Five* - The Classroom Experience. The process outcomes and activities of each class are explored in depth. For a full understanding of the student work, the multimedia material is best accessed as such on the CD. This chapter deals with descriptions of process, patterns of process outcomes, opinions, reflections, and an analysis of similarities across classes.

*Chapter Six* - An Interactive Multimedia Learning Framework. In order to place the classes in a broad framework of multimedia and learning, three models are proposed. Each model comprises a complementary teaching/learning pair. The theory, resource requirements and process outcomes of each model are discussed. These models draw together the theory of Chapters Two and Three with an analysis of the differences between the classes of Chapter Five. It also compares these findings with recent studies by other researchers.

*Chapter Seven* - Conclusions and Implications. The motivation and purpose of the study are re-iterated, prior to identifying key findings which establish its unique contribution to the field of education technology research. The implications of these findings are explored for teachers, researchers, designers and learners. The thesis concludes with a possible scenario of the self-regulated technologically literate learner of the future.

*Bibliography* - Lists the citations of material directly referenced in this thesis.

*Appendices* - Provide examples of class worksheets, copies of questionnaires and interview questions, summaries of class activities, and more detailed descriptions of student products.

*Maps of The Garden* - Illustrate key areas in *The Garden*, together with a brief description of their design rationale, functionality, and navigation options.

It is now time to switch to high power objective— to turn our sights on the typical classroom environment from a constructivist perspective. This is the point of reference for subsequent discussion on the impact of educational technology on the relationships among teacher, student and designer.

One specific use of educational technology— the construction of interactive multimedia— becomes the driving force behind the organisation of classroom activities within the classes. The open nature of such a task is in harmony with constructivist principles of learning. The computer is an orchestrating tool— a decentred participant in a very human endeavour— the construction of knowledge.

All three key players — teacher, student and designer, are regarded as learners, in this endeavour to uncover the positive roles for educational technology in the process of learning. Chapter two introduces the classroom players.

## Chapter Two - The Typical Classroom Environment

### Introduction

The merging of computer-mediated educational technology with the typical classroom environment represents an opportunity for synergy between two roles—that of the classroom teacher and that of a person who is usually known in research literature as an instructional designer.

The teacher is focused on the use of well-developed interpersonal skills and a body of knowledge and strategies to assist the learner in a relatively flexible manner throughout the learning process. This is usually accomplished within the social/political context of curriculum-centred, teacher driven instruction.

The instructional designer, emerging from a diverse range of disciplines, with potentially a deep understanding of learning theory, psychology, artificial intelligence, systems analysis, project management and computer science (Schiffman, 1995) is focused on the development of learning environments for learners they usually never meet. When such environments are computer classrooms, the instructional designer is specifically referred to by the researcher as an "educational software designer".

Teachers and educational software designers are in principle working towards a common goal for students, albeit through different means with different tools. There should be an overlap in their respective roles which can be explored for the benefits of learning. Future classrooms will include computer-mediated technology. If this technology is to be used effectively for learning, rather than for the instruction of students by educational software designers who assume total responsibility for the learning process via the transmission of educational resources (Johnsen and Taylor, 1995), then harmonious relations, good communication and epistemological unity between teachers and educational software designers will be important.

Papert (1991) discusses the nature of that epistemology, and argues that the widespread infusion of computers into schools as a technical infrastructure will allow the system to be less technical in its methodology, and thus increase the potential for learner-centred humanistic education. He distinguishes between two different concepts held by educators—megachange and incremental evolution:

> *"The dominant paradigm is the Band-Aid— most reform tries to jigger the curriculum, the management of schools, the psychological context of learning.*

*... For stable change a deeper restructuring is needed— or else the large parts of the system you didn't change will just bring the little parts you did change back into line. We have to seek out the deeper structures on which the system is based." (Papert, 1991, p24-25)*

Yet Papert does not see the computer as an agent which will determine the direction of change:

*"... much thinking about the computer goes in the opposite direction, strengthening the idea of teaching as a technical act, supporting centralization in organization of institutions and of ideas. I've seen models of a school of the future in which there's a computer on every desk wired up to the teacher's computer, so that the teacher can see what every child is doing." (Papert, 1991, p25)*

The response to computers by individuals within a school determines the trend towards megachange or Band-Aid tactics. Centralised computer control represents the Band-Aid approach. While it diminishes the likelihood of creative computer use for learning, it does not stop the individual teacher from using the computer in a learner-centred manner with software Papert likens to a "trojan horse". Such software satisfies administrative requirements of computer literacy, while also challenging at a deep level the nature of knowledge.

Framed by some of the current goals for western education, this chapter explores the domain of the classroom from the teacher's perspective. A constructivist approach to learning is discussed. Computer technology is not a focus. It is regarded as a tool. The educational software designer's perspective will be introduced in the following chapter. All three perspectives—student, teacher and educational software designer, are then integrated in an authentic classroom environment.

## 2.1 Current Goals for Education

A practical and versatile goal of school education would be the transfer of knowledge to the solution of "real–life" problems. The perceived failure of some western education systems to provide learners with the basic three R's, combined with a pressure to prepare students to cope with vast quantities of information and rapid change, has led to a call for the teaching of "higher order skills" (Resnick, 1987). These are described as critical thinking and logical reasoning by philosophers, metacognition by developmental psychologists, and cognitive strategies and heuristics by cognitive scientists. Educators refer to study skills and problem solving.

In attempting to define higher order thinking, Lauren Resnick (1987, p3) lists situations in which we can recognise the occurrence of higher order thinking. This form of thinking:

- is non algorithmic— the path of action is not fully specified in advance.
- is complex— the total mental path is not visible from any vantage point.
- yields multiple solutions— each of these have costs and benefits.
- involves nuanced judgment and interpretation.
- applies multiple criteria, which sometimes conflict.
- involves uncertainty— not everything which bears on the task at hand is known.
- involves self-regulation of the thinking process.
- involves imposing meaning— finding a structure in apparent disorder.
- is effortful— considerable mental effort is involved in the elaborations and judgments required.

While higher order thinking has always been espoused in elite education, the support for these skills in mass education raises the unresolved tension between the goals and methods of elite and mass education:

> *"Mass education was, from its inception, concerned with inculcating routine abilities: simple computation, reading predictable texts, reciting religious or civic codes. It did not take as goals for its students the ability to interpret unfamiliar texts, create material others would want and need to read, construct convincing arguments, develop original solutions to technical or social problems.*
>
> *...Standardization was a means of ensuring that at least minimal curriculum standards would be met... " (Resnick, 1987, p5)*

The extension of primary school-based mass education into the high school system raises the debate over what the appropriate curriculum ought to be for secondary schools designed for everyone, and the tension between vocationalism and traditional disciplines has yet to be resolved. Employers now seek general thinking skills (Slovin and Woolf, 1989) which reflect more the output of the elite systems of the past. The current challenge is whether these can be included in everyone's curriculum, in order to allow all individuals the chance to become competent thinkers.

As an organising framework for discussion, the typical classroom environment has been represented by the researcher as a model composed of a number of highly variable key factors. This construction (see *Figure 2.1*) is aimed at facilitating comparisons between the role of the classroom teacher and the possible roles of the educational software designer, who is discussed in Chapter Three.

## 2.2 Aspects of the Typical Learning Environment

The key climatic factors to be discussed in this chapter are represented in *Figure 2.1*:

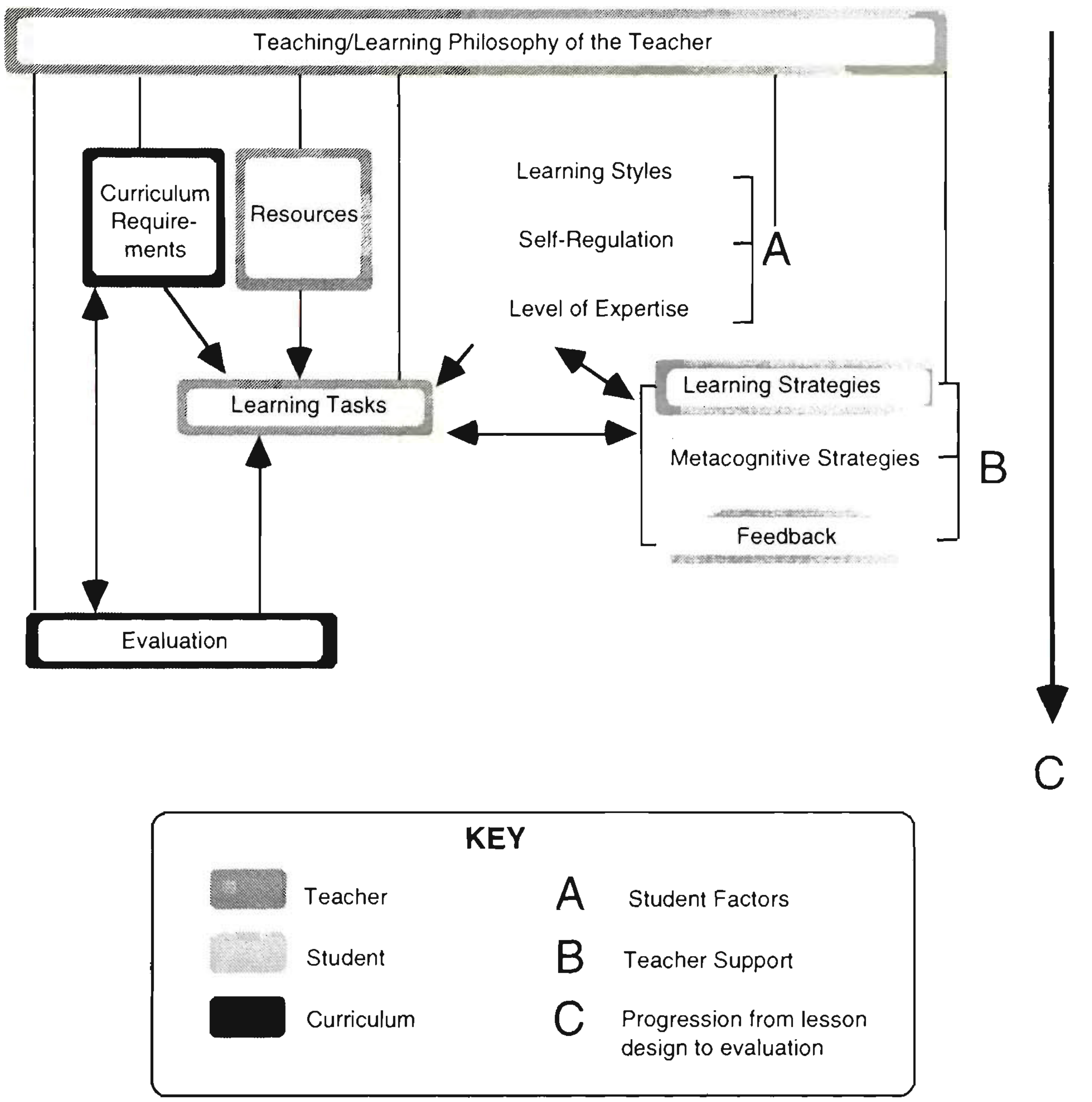


*Figure 2.1 : Factors Affecting Classroom Experiences (Author's Model)*

The overarching tone of the classroom is set by the teaching/learning philosophy of the teacher. Through that perceptual filter, the next cluster of factors interact to provide the unique classroom experiences. The teacher must be aware of what the curriculum requires of the learners— what knowledge, skills and attitudes are to be acquired and developed, and the physical and intellectual resources available. This interacts with the characteristics of the group of learners — what stage of a course they are at, why they are studying, and the range of learning styles, to assist the formulation of appropriate learning tasks within a particular environment. Teacher support is ongoing, and assists the learners through the discussion and modelling of learning strategies, the setting of goals, the monitoring of strategies, and provision of feedback — a cluster of interpersonal skills very hard to provide by alternate means. A highly significant constraint on the initiative and creative flair shown by a teacher is the level and type of evaluation required by the curriculum.

This externally determined factor frequently favours breadth of low level knowledge over depth of knowledge processing and higher order skills. For many teachers, the impact of evaluation pressure is to slowly engulf the philosophy factor and remove much of the creative self-expression and individuality from teaching. With time constraints and an overburden of curriculum objectives, there is no support for the continued development of the interpersonal skills necessary to individually foster higher order thinking and cooperative or collaborative group work with students.

Each of the factor clusters in *Figure 2.1*—teaching philosophy, what the curriculum requires of the learner, characteristics of the learner, available resources, learning tasks, support "tools" and the shaping role of evaluation will now be discussed in depth. The number of possible permutations and combinations of these key factors develops rapidly to reveal the complexity of the typical classroom environment.

### 2.2.1 Teaching Philosophy — Constructivism and its Precursors

Teaching is a very personal process which brings out the 'implicit theories' of the teacher:

> *"People's behaviour and opinions are the visible branches of an enormously complicated underground root-structure of ideas and assumptions, most of which we do not even know we have. These 'implicit theories', as I shall call them, not only determine the way we behave: they also determine how we approach anything new— how we think about it, how we react to it, how we learn about it, even how we actually see it." (Claxton, 1990, p 6)*

According to Claxton (1990), these implicit theories aren't logical— they can be piecemeal and purpose-built, and are powerful determinants of our spontaneous behaviour. They may be picked up unconsciously and uncritically, and have a tendency towards simplification, overgeneralisation and dogmatism. They emerge from experience, the everyday social world, and from what we are taught. An individual can espouse one theory, yet turn around and support another through different actions, often without awareness of the disparity.

Claxton (1990) regards the process of learning to teach as one which is primarily personal, practical and emotional—based around relationships, rather than an intellectual or a technical process. In order to develop or alter a teaching style, teachers need to become aware of their prior assumptions, and to uncover implicit theories and beliefs about children, discipline and most importantly learning, as this will determine the way they think about school.

Learning theories attempt to answer how knowledge is acquired, how knowledge interacts within the mind, and therefore such related issues as how learning fails, why we forget and how people differ in the ease and accuracy of what they learn. These theories must also address how knowledge is structured and organised in the mind:

> *"This last question is the most basic of all. Learning theories concern internal changes in knowledge, and so they must presuppose some model, even if it is only latent, of the nature of the mind itself. Usually we can find, behind each learning theory, a basic metaphor for the mind that exerts considerable influence in the way learning is construed." (Claxton, 1990, p 42)*

A range of mind metaphors are reviewed by Claxton (1990). These have been summarised and are presented in *Table 2.1* on the following page.

In reviewing the major changes in learning theories, as exemplified by the mind metaphors, Claxton (1990, pp 55-56) identifies seven trends:

- a shift from the view of knowledge as discrete bits to knowledge integration
- a recent view of concepts as more ill-defined
- more interest in processes of learning and thinking than the structural components of the mind
- the tying of certain processes more closely to mental jobs or physical situations
- increased importance placed on the strategies of individuals
- a change in the view of learning, from the constant addition of new information to the possibility of tuning, re-structuring and even deletion of outmoded material
- the view that the process of learning takes place through the use of what we already know

| *Metaphor* | *Explanation of Knowledge* |
|---|---|
| Mind as Wax | Impressions in wax; can be melted or overstamped; wax may be too hard to stamp |
| Mind as Aviary | Birds caught; they are discrete entities; organisation is implied; can catch the wrong bird |
| Mind as Bath | Soap in a bath; can be difficult to find the right one; can dissolve or slip out of the bath |
| Mind as Switchboard | Establishment of links strengthened by practice; doesn't explain knowledge complexity |
| Mind as Library | Books in an organised library; learning—putting things in their right place; remembering—searching shelves |
| Mind as Computer: First Version | New inputs processed in short term memory for transfer to a storage location in long term memory |
| Mind as Net | Multiple kinds of links; knowledge woven in complex networks (semantic memory); declarative(information) versus procedural (search mechanism) knowledge |
| Mind as Dictionary/Diary | Semantic dictionary and also an episodic diary; understanding is the creative modification of what we know; concepts are now fuzzy; learner experience vital |
| Mind as Computer: Second Version | A collection of sub-minds each specialised for a certain task; different ways of thinking, learning & operating |
| Mind as Minitheories | Multiple 'frames', 'scripts' or 'minitheories' which are designed to cope with familiar scenarios |

*Table 2.1: Metaphors for the Mind (Claxton, 1990, pp 43-55)*

Learning is now regarded as a change in the way we think as well as a change in what we know. Our existing knowledge markedly influences our interpretation of new material. This general approach to the mind is known as *constructivism*. A teacher who acknowledges the constructivist view of learning is often said to have adopted a constructivist philosophy.

*Objectivism* presents a contrasting view of learning. Objectivists see knowledge as separate from knowing. To an objectivist, humans can acquire knowledge in an objective manner through the senses. An education program devised by objectivists emphasises the learning of knowledge as truths to be reproduced on tests (Lakoff cited by Tobin and Dawson, 1992, p 82). Objectivists believe in the existence of reliable knowledge about the world. They also believe that all learners gain the same understanding from what is transmitted by a teacher.

In the words of von Glasersfeld, *constructivism* is:

> *"a theory that assumes knowledge cannot exist outside the bodies of cognizing beings. Constructivism recognises a reality that exists independently of cognizing beings—i. e., the universe would continue to exist in a physical sense if there were no longer persons to think about its existence. However, the experiences of cognizing beings are constructs that are shaped by what is known and understood by the individual." (cited by Tobin and Dawson, 1992, p83)*

Experience involves an interaction between the senses and reality, and knowledge is a construction of reality, adapted as a result of successive experiences and reflections. Knowledge is viewed as the product of learning, and consists of beliefs and other propositions, images, metaphors, metonymies and bodily actions. Tobin and Dawson (1992) see constructivism as a set of beliefs that can be used to guide action. They note the considerable impact of constructivist philosophy on curriculum design:

> *"From a constructivist perspective, a curriculum designed by outsiders to be implemented by teachers is doomed. The best that can be done is to provide resources and a way of thinking about how teachers and their students learn." (Tobin and Dawson, 1992, p 84)*

A curriculum can be planned, however, with constructivism as a referent. Based on constructivist beliefs, it is:

> *"concerned with the social aspects of learning in which students make sense of experience in terms of extant knowledge" (Tobin and Dawson, 1992, p84)*

Jonassen (1991b) describes the objectivist stance as the expectation that learners who are told about the world can then replicate its structure in their thinking. The constructivist stance acknowledges that the mind filters input from the world, and is instrumental and essential in interpreting events, objects and perspectives on the real world, to produce a personal knowledge base that is unique.

The distinction between the objectivist and constructivist views on knowledge and learning has impacted considerably on the nature of science education. and deserves a special mention.

### *Constructivism in Science Education*

Science education attempts to blend the scientific way of knowing with the everyday reality for students. The researcher's background experience in scientific research and science education highlighted an awareness of the gulf between the two "languages" of science. Considerable research into constructivist learning has occurred in this complex and abstract subject domain, and the findings deserve a special mention. Driver & Oldham (1986) identify three fruitful theoretical developments— the nature of children's ideas, the constructivist view of learning, and the view of learning as conceptual change.

On the first issue, children's conceptions of the natural world do not follow the scientific view and are frequently maintained outside the formal school setting. On the second issue, the constructivist view of learning suggests that the sense made of any event is dependent on the situation, on the individual's purposes and on the individual's active construction of meaning. Intents, beliefs and emotions are as important as conceptualisations, and prior experience influences perceptions and interpretations of events. The learning process is active, and the responsibility of the learner. On the third issue, the cognitive perspective among psychologists views learning as construction of 'models' or 'schemes' used to interpret experience. Knowledge is a series of structures and learning changes the structures, either by adding, modifying or re-structuring.

Driver and Oldham (1986, pp 110-111) hold the following views about learning:

a. Individuals are purposive - they actively interact with the environment to make sense of it

b. Knowledge is constructed by individuals through social interaction and experiences with the physical environment

c. Individuals' knowledge and belief structures influence the meanings they construct in a given situation

d. Constructing meaning is an active process - a learner generates possible hypothetical meanings and checks for these to 'fit' the situation.

e. Understanding is not the same as believing

f. Learning scientific ideas involves conceptual change - "we recognise the importance of talk and other informal modes of communication in enabling pupils to make their ideas explicit and hence available for reflection and change."

They acknowledge the impact of a constructivist view of learning on the process of curriculum development—the learners' contributions are as meaningful as the learning situation. The curriculum is thus viewed as "the set of learning experiences which enable the learners to develop their understanding." It is seen as a program of activities. Curriculum development has to be reflexive, and incorporate decisions on content, students' prior ideas, an understanding of the learning process and practical teaching knowledge (Driver & Oldham, 1986).

Roth (1990) discusses the issue of meaningful conceptual understanding in science, and ways teachers can support this deeper kind of learning. Scientists view conceptualisations of their disciplines as critical, and these do not match the traditional topic approach of school science curricula. Cognitive psychologists emphasise the critical role of prior knowledge actively clustered in memory as schemata:

> *"A schema is a cluster of knowledge specifying a set of concepts and the relationships among them that describe a more complex superordinate concept." (Roth, 1990, p143)*

Learning as conceptual change relates new experiences to what the person already knows. If a relevant schema is not activated, the knowledge can be learnt by rote, but it is not linked to prior knowledge or other concepts. If there is a conflict between prior knowledge and new knowledge, the new knowledge can be dropped. If new knowledge fits into an appropriate schema, the information is assimilated.

Students bring their everyday concepts to class, and in order for *meaningful conceptual change learning* to occur, they must take apart or re-arrange these everyday schemata in order to integrate the scientific concepts appropriately. They need to be aware of the conflict and work hard both cognitively and metacognitively to resolve it. Since their everyday concepts are linked in a complex network, this re-structuring process is very threatening as it has widespread repercussions. It is much easier to ignore changing a concept with multiple links to other concepts, than to risk total confusion.

Roth (1990) notes that student errors are often not random, but based on firmly held patterns of thinking anchored in everyday experience. Traditional instruction focuses on students memorising facts, and plugging these into formulae. In textbook-based classrooms the student misconceptions are never voiced, and the ideas of scientists are learnt. In inquiry classrooms with a hands-on approach, students air their views, but these are never resolved with the view of the scientist which is often taught at the end, leaving no time for students to re-construct their concepts. Formal instruction normally does not help students think about the relationships between their everyday notions about scientific phenomena and scientific explanations of the same phenomena. Roth urges:

> *"Instruction that supports meaningful conceptual learning must help students recognise and reconcile the differences between two different worlds of thinking. Students need to be helped to re-arrange their own ways of organising concepts and to make new kinds of conceptual connections." (Roth, 1990, p157)*

> *..."Strategies that can be used in the classroom settings to capture the richness of students' conceptual ecologies would enable us to better understand the impact of specific instructional approaches. In addition, it is critical that we begin to assess a fuller range of learning outcomes." (Roth, 1990, p165)*

Research in science education acknowledges the influence of the individual's knowledge base as a starting point in the move towards deep conceptual understanding of advanced disciplinary knowledge.

Duffy (1995) counters two common misinterpretations of the term constructivism—a constructivist philosophy does not leave the learner on their own to discover, and it does not allow for the acceptance of any construction without the challenge of discourse. The role of the teacher and fellow learners, according to Duffy, is to challenge the learner's perspective.

As we move on to view the needs of the learners, it is worth looking at the constructivist view of learning from the learner's perspective. Perkins (1991b) highlights three ways constructivism can place a sharp load on the learner—cognitive complexity, managing a task themselves, and what he terms "buying in" to this more involved method of attaining knowledge.

Since much constructivist education is aimed at confronting the learner's naive models and comparing these to another model, the cognitive load of this comparison is high. When you add task management to this load, without scaffolding or coaching by the teacher, it is not hard to see why some students simply ask for the "right" answer, rather than "buying in" to the more difficult task. The learner's view of constructivism will be highly coloured by their teacher's understanding of constructivism, and the importance their teacher places on knowing the learners, and guiding them through a confronting process of knowledge re-construction.

### 2.2.2 Needs of the Learner — Knowledge

While there have been some interesting metaphors for knowledge and the mind, as indicated in *Table 2.1*, the more appropriate translation of "knowledge" in terms of educational goals encompasses the acquisition of:

- facts in specific subject areas
- procedural skills such as reading, language use and problem solving, and
- higher order thinking skills to access and apply the above to meaningful problems
  Derry (1990)

Curriculum documents set out the goals of education, and progressively refine communication with teachers to a point where a series of objectives are listed in the cognitive, affective and psychomotor domains, or a list of outcomes is produced as the target achievement at the end of instruction. Whatever educational theory influences the structure of the documents, they serve to answer the same question —what should the students be able to do at the end of a period of instruction? The answer to the next question— how will I know they can do that — provides the format for evaluation.

Curriculum and evaluation are the driving force and measure of instruction. Unless they work in harmony, the role of the teacher is difficult to define. When changes are made in the curriculum, there is no motivation to implement these changes unless the evaluation process is adjusted accordingly. Evaluation measures which emphasise facts and low level application of knowledge provide teachers with little incentive to take valuable time extending students in problem-solving and higher-order thinking. If the call to higher-order thinking and problem solving is genuine, adjustments to public evaluation systems such as those used at the end of secondary school will be required.

Higher-order thinking and autonomous learning make steep demands on the learner— independent, self-regulated goal setting and monitoring. They need to develop a repertoire of generic processing strategies and sound metacognitive skills. To understand the implications of the push for higher-order thinking and problem-solving skills, it is necessary to view the target of learning—knowledge — in some detail.

Alexander, Schallert and Hare (1991) set out to challenge and motivate cognition and literacy researchers to explicitly define the many terms which have recently proliferated around constructs related to knowledge. In the literature they review, *knowledge* encompasses:

> *"all that a person knows or believes to be true, whether or not it is verified as true in some sort of objective or external way." (Alexander, Schallert and Hare, 1991, p317)*

In a first attempt at bringing order to usage, they construct a loose and fluid conceptual framework (*figure 2.2*) into which definitions are subsumed. Definitions alone do not make sense unless they are seen in relation to one another.

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*Figure 2.2: Fluid Model of Prior Knowledge (Alexander, Schallert and Hare, 1991, p324)*

Several assumptions accompany this visual representation:

- the perspective is that of the individual learner
- forms or types of knowledge are represented, not how they operate on thinking or learning
- any form can contain declarative, procedural or conditional knowledge. Declarative knowledge is factual. Procedural knowledge is the use of that knowledge in processes and routines. Conditional knowledge is when and where this knowledge is applicable.

Explicit knowledge is represented by the two interacting planes within prior knowledge— conceptual knowledge and metacognitive knowledge. There is a fluid relationship between these planes and tacit knowledge. Explicit knowledge represents only a small fraction of an individual's knowledge base.

Sociocultural knowledge is viewed globally in the literature as a pervasive filter through which all experiences must pass. While sociocultural knowledge can be made explicit when addressed directly, the cultural milieu influences the way the learner talks, thinks and conceptualises. This form provides a lining inside the sphere of knowledge.

Construction is the interface between dynamic prior knowledge and the external environment. It is a bridge between the individual's prior knowledge and other human processes, and thus extends beyond the confines of the knowledge sphere.

Each of these boxes can be further defined:

- Conceptual knowledge (*figure 2.3*) is a complex construct which represents the individual's knowledge of ideas — it is the realm of knowledge associated with the term schemata, and is broadly divided into content and textual schemata.

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*Figure 2.3: Conceptual Knowledge (Alexander, Schallert and Hare, 1991, p327)*

Content knowledge can be formally and informally acquired, and moves through a domain into a discipline as it is organised around fundamental principles. Discourse knowledge relates to language and its uses, at the word, sentence or text level, and includes audience, style and tone to communicate effectively. Word knowledge overlaps both content and discourse knowledge, since there are two components to word knowledge— the label, and the concept represented by the label.

- Metacognitive knowledge (*figure 2.4*) encompasses three general areas— knowledge of yourself as a thinker and learner (what you do best, how you rate with others, how you think you learn), knowledge of tasks (reading for understanding is harder than reading for memorising) and strategic knowledge (knowing what I do best and how tasks differ, I will adopt this strategy for this task, then check my progress). However, metacognitive knowledge does not simply deal with cognitive matters, but encompasses the affective domain and motivation through effortful plans and goals, which direct strategy use.

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*Figure 2.4: Metacogntive Knowledge (Alexander, Schallert and Hare, 1991, p328)*

- The knowledge interface is termed construction (*figure 2.5*). Synonyms for construction are representation, interpretation and understanding. It includes instantiation of conceptual knowledge and the textbase. Instantiation occurs from the interaction of existing knowledge structures built on prior experiences with available information from ongoing experiences. The learner builds a meaningful framework from existing knowledge that will facilitate the interchange between what is already known and what is to be understood. Synonyms for instantiation include mental model, situation model, and insight. The separate existence of the textbase is included by Alexander, Schallert and Hare (1991) to represent researchers who place emphasis on the special nature of language, where understanding of written or oral communication is involved.

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*Figure 2.5: The Construction, or interface plane, between prior knowledge and on-going processing demands (Alexander, Schallert and Hare, 1991, p330)*

Constructivism is a philosophy which places the prior knowledge of the learner centre stage. The fluid construct of the individual's prior knowledge produced by Alexander, Schallert and Hare (1991) gives an indication of the complexity of knowledge forms. Concepts are one component of knowledge worthy of discussion.

Klausmeier (1990) describes concepts as the "tools of thought" — a mental construct of something concrete or abstract. An individual constructs a concept — represented internally and stored in memory, from both informal and formal learning experiences. Concepts are attained at different levels of understanding and use. Attributes of a concept may be intrinsic (invariant properties, such as a triangle has three sides), functional (a saw is used to cut) or relational (south is the cardinal point opposite north). Attributes are learnt with a concept and are used to relate it to other concepts and identify examples.

> *"The defining attributes of a concept are those invariant intrinsic, functional and/or relational attributes that together differentiate the examples of any given concept from examples of all other concepts." (Klausmeier, 1990, p96)*

Misconceptions occur when incorrect defining attributes are ascribed to a concept. This is not the same as an incomplete concept attained at a lower level. Klausmeier's theory of concept learning and development describes four successively higher levels of concept understanding, the mental processes involved, uses of a concept at a level and instructional conditions which facilitate that level of attainment. The four levels are concrete, identity, classificatory and formal:

- at concrete level, an item is discriminated as an entity different from its surrounds.
- at identity level, the item can be recognised in a different context.
- at classificatory level, two or more examples of the concept are generalised as equal. At the mature classificatory stage, most defining attributes have been learned, the concept has a name and is represented both in imagery and semantically.
- at the formal level, there are four requirements which need verbalisation: (1) identify and name any example of a concept (2) identify and name all the defining attributes of a concept (3) define the concept in terms of its attributes (4) evaluate how any example of a concept differs form other concepts in terms of defining attribute (Klausmeier, 1990)

This formal level facilitates problem solving. The mental processes involved across these levels include selective attention, discrimination and generalisation, hypothesising and meaningful reception learning. To hypothesise involves making a best guess as to what the concept is, based on the information you have, then testing the hypothesis against reality (Klausmeier, 1990).

Lawson et al (1991) test the constructivist hypothesis that the acquisition of novel domain-specific concepts (declarative knowledge) depends upon general procedural knowledge (ie., general thinking skills). An alternate view might be that concept acquisition depends alone upon the presence of previously acquired well-organised domain-specific concepts. Lawson et al predict that developmentally skilled students who process information in a hypothetico-deductive way acquire the concepts while unskilled students don't:

> *"Concept acquisition, seen in this light, is not viewed as a purely abstractive process but rests on the ability to generate alternative hypotheses and test them through their deduced consequences. In this sense one's conceptual knowledge (an aspect of declarative knowledge) depends upon one's procedural knowledge. As one gains skill in using this hypothetico-deductive reasoning pattern, concept acquisition should become easier." (Lawson et al, 1991, p962)*

They don't question the role of prior knowledge in concept acquisition, merely emphasise the additional role of procedural knowledge. Hypothetico-deductive reasoning is defined as :

> *"that pattern of reasoning in which intuitively generated ideas are proposed as hypotheses, their consequences deduced, and evidence of some sort is compared with those deduced consequences to allow the rejection or retention of initial hypothesis." (Lawson et al, 1991, p956)*

The terms intuitive (empirico-inductive) and reflective (hypothetico-deductive) are used instead of Piaget's concrete and formal operations. They find that non reflective thinkers are able to generate an hypothesis (in a limited sense of the term), but they do not seek nor do they recognise data that disconfirm the hypothesis. They either reject the data or are left with the uneasy sense that all is not right, but are unable to proceed. This supports a more general conclusion that deficiencies in reasoning skills are a cause of academic difficulties. The educational implication is that students need help acquiring general reasoning patterns. All students can acquire the concepts with help, but without the hypothetico-deductive reasoning pattern, the purely intuitive thinkers cannot learn the concept by themselves in a self-directed fashion.

> *"Our results indicate that the childlike thinker (the intuitive thinker) is not even able to construct first-order/descriptive concepts without the "powers of*

*reflection" referred to by Inhelder and Piaget, at least without the aid of knowledgeable peers or adults. This implies that reflective students will have an advantage over intuitive students in acquiring virtually all the concepts taught in science classes..." (Lawson et al, 1991, p969)*

Brown, Collins and Duguid (1989) explore the breach between learning and knowledge use in their discussion of situated cognition and the culture of learning. They abandon the notion that concepts are abstract, self-contained entities and see knowledge as a product of activity and situations. Any separation between knowing and doing in didactic methods of education is considered artificial. Concepts are seen in a much softer light than the rigid interpretation of Klausmeier, 1990:

*"a concept, for example, will continually evolve with each new occasion of its use, because new situations, negotiations and activities inevitably recast it in a new, more densely textured form. So a concept, like the meaning of a word, is always under construction." (Brown, Collins and Duguid, 1989, p33)*

Conceptual knowledge is regarded as a set of tools, which can only be fully understood through use. People who use the tools build a rich implicit understanding of the tools and the world in which they are used, since it is this world which determines the use of the tools. Brown, Collins and Duguid (1989) see conceptual tools as a reflection of the cumulative wisdom of a culture and the insights and experience of individuals within that culture:

*"Activity, concept and culture are interdependent. No one can be totally understood without the other two. Learning must involve all three." (Brown, Collins and Duguid, 1989, p33)*

Cognitive apprenticeship is a method which seeks to enculturate students into authentic practices through activity and social interaction. Authentic activity is defined by Brown, Collins and Duguid (1989) as "the ordinary practices of the culture." Problem solving in this context is within a rich environment, which contributes importantly to indexical representations developed through engagement in a task. Teachers or coaches make explicit their tacit knowledge, model their strategies, and scaffold students through the authentic task. With developing confidence a student is free to contribute his/her own inventive heuristics and can become both more autonomous and collaborative. Strategies identified on task reflection can be shared. Knowledge is distributed across the social and physical environment.

The more regular form of problem solving which is endorsed in many classrooms involves abstract concepts, and relies on a firm understanding of the decontextualised structure and interrelationship of key concepts in a knowledge domain, coupled through conditional knowledge with an ability to use the relevant procedural skills of that domain. Such problems are solved as a mental exercise, devoid of authentic activity. This complex activity requires goal setting, planning and monitoring— a role taken on by metacognitive knowledge.

This component of the learner's prior knowledge, which is often not considered, exerts a tremendous influence on the learning process via decisions which are filtered through affective and motivational factors. Hence, for the teacher, an appreciation of the complexity of the knowledge construct, and awareness of specific curriculum and evaluation requirements, provides only some of the information needed to determine appropriate learning tasks. Whether these tasks can be authentic learning tasks is a more challenging issue which is discussed again later. Vital knowledge which the teacher needs is an awareness of the potential range of characteristics of a group of learners.

### 2.2.3 Characteristics of the Learner

#### Learning Style

Learning style is a very broad term which refers to a learner's characteristic and preferred ways of gathering, interpreting, organising, and thinking about information (Davies, 1993).

Schmeck regards the more narrow term cognitive style as:

> *"the stable, traitlike consistency in one's approach to attending, perceiving and thinking" (Schmeck, 1988, p8)*

and considers the major dimension of cognitive style affecting learning places global—holistic attention, perception and thinking at one end, and focused—detailed attention, perception and thinking at the other. Other terms for this continuum include field dependent and field independent, holist and serialist, right-brained and left brained, and simultaneous and successive processing.

Claxton and Murrell (1987) group many different models of learning styles into four categories —personality, information processing, social interaction and instructional preference. Several models from each category are summarised and tabled (*Tables 2.2 - 2.5*), with a brief note of their implications for the classroom:

| *Example of Model* | *Implications for the Classroom* |
|---|---|
| *Field Dependence/ Field Independence (FD/FI)*<br><br>FI - more analytical, autonomous, relate more to Maths/Science<br><br>FD - more influenced by authority and peers; prefer social sciences and democratic class practices (Witkin, 1976) | Students can be expected to differ widely in their desire for autonomy, the influence of their peers, the subject choices they make and their ability to remove ideas from a context and relate them to a new situation.<br><br>Some need strong guidance and stepwise direction, while others value creative freedom. |
| *Myers-Briggs Type Indicator*<br><br>Based on Jungian Theory, students will vary on 4 scales:<br>Extroversion/Introversion<br>Sensing/Intuition<br>Thinking/Feeling<br>Judging/Perception<br><br>Excellent test to promote dialogue with students (Myers, 1976) | Intuitive types naturally score better on tests of reading and writing aptitude.<br><br>Teachers ask questions according to their preference for sensing or intuition. Sensing types ask low level detail with specific answers, while intuitive types ask questions that call for synthesis, imagining and hypothesising. Each need to find balance. |
| *Reflection/Impulsivity*<br><br>(Kagan, 1965) | Students can be taught to be more reflective.<br><br>Dramatic implications for multiple choice testing at both ends of the spectrum, where students can make rash decisions if they are too impulsive, or freeze in indecision if they are too reflective. |

*Table 2.2: Some Personality Models of Learning Style (Claxton and Murrell, 1987, pp 8-17)*

The personality models (*Table 2.2*) and information processing models (*Table 2.3*) focus on the individual learner across a broad range of contexts.

| *Example of Model* | *Implications for the Classroom* |
| --- | --- |
| *Holists and Serialists*<br><br>Holists - use a global top-down approach, connecting theory and practice<br><br>Serialists- develop understanding through logical, sequential well-defined steps; theory and practice are covered separately<br>(Pask, 1976) | Holist and serialist describe information processing strategies.<br><br>Holists tend to be comprehension learners, who are good at overview description building and use analogy.<br><br>Serialists are operation learners, who are good at providing evidence and procedure building and use logic.<br><br>The goal for versatile learning is to use both kinds of strategies, not rely on one. |
| *Deep-Elaborative and Shallow-Reiterative Processors*<br><br>Deep processing: more attention is given to meaning and thinking - analysing, synthesising and linking to personal examples<br><br>Shallow processing: words are repeated and memorised in their original form - little re-wording or restating or rethinking done<br>(Schmeck, 1981) | Teachers can help students develop a deeper processing style by setting tasks which require them to elaborate on material, link it to their own experiences, and build a case for a particular viewpoint.<br><br>This must be balanced with appropriate test items which go beyond shallow processing and simple memory work - which seek comprehension of meaning. |
| *Experiential Learning*<br><br>4-step learning process:<br>- concrete experience<br>- reflective observation<br>- abstract conceptualisation<br>- active experimentation<br><br>How you take in and process information leads to 4 types:<br>- Divergers<br>- Assimilators<br>- Convergers<br>- Accommodators<br>(Kolb, 1984) | Divergers and accommodators are more interested in people, while the assimilators and convergers are more interested in abstract ideas and things.<br><br>As a teacher you need to provide activities which ask for alternate solutions (diverger), comparison and contrast (assimilator), specific information (converger) and practical application (accommodator).<br><br>The significance of these styles is their diversity, and the aim is to promote the use of all styles by each student, not to categorise a student in one style. |

*Table 2.3: Some Information Processing Models of Learning Styles (Claxton and Murrell, 1987, pp 21-33)*

The next group of models relates to the social and motivational aspects of the traditional site of "learning" - the classroom (*Table 2.4*).

| *Example of Model* | *Implications for the Classroom* |
| --- | --- |
| *Grasha & Reichmann Student Learning Style Scales*<br><br>Categories were:<br>- independent students<br>- dependent students<br>- collaborative students<br>- competitive students<br>- participant students<br>- avoidant students<br>(Reichmann & Grasha, 1974) | These categories deal with social and emotional needs of students, as well as content scope.<br><br>Definite preferences are shown for student centred versus teacher centred classrooms. Where peers are valued, it can either be as competitors or collaborators.<br><br>The scope of content covered by students does not relate to participation or peer affiliation. It is a function of intellectual curiosity and motivation. |
| *Fuhrmann & Jacobs*<br><br>Three student styles:<br>- dependent<br>- collaborative<br>- independent<br><br>Each are required in different situations, so none is seen as bad.<br>(Fuhrmann & Grasha, 1983) | Dependent learners in a new area need structure and direction, external reinforcement and encouragement. The teacher is the *expert* who designs and transmits, then grades.<br><br>Collaborative learners with some knowledge they wish to test out need interaction and derive esteem from peers. The teacher is a *co-learner* who models, manages, questions and provides resources and feedback.<br><br>Independent learners with a high level of knowledge need internal awareness, time, non-judgmental support and experimentation. The teacher is a *facilitator*, who provides, consults, allows, listens, negotiates and evaluates. |
| *Eison*<br><br>The LOGO II Instrument identifies four orientations:<br>- high learning and grade<br>- high learning low grade<br>- low learning high grade<br>- low learning and grade<br>(Eison, 1979) | Students have different attitudes to grading and learning.<br><br>High learning orientation views the classroom as a place to find important information and ideas.<br><br>High grade orientation views the classroom as a place to endure testing to obtain a certificate.<br><br>There is a significant move from external grade orientation to internal learning orientation with age. |

*Table 2.4: Some Social Interaction Models of Learning Styles (Claxton and Murrell, 1987, pp 40-46)*

The final group of models deals with instructional preference — which teaching method you prefer (*Table 2.5*).

| *Example of Model* | *Implications for the Classroom* |
|---|---|
| *Hill - Cognitive Style Mapping*<br><br>Comprehensive coverage of:<br>- symbols and their meaning<br>- cultural determinants<br>- modalities of influence<br>- memory<br>- cognitive style<br>- teaching, counselling & admin style<br>- systematic analysis decision making<br>(Hill and Nunnery, 1973) | Hill developed a comprehensive test which could be taken and analysed in one hour.<br><br>Students at a number of colleges were tested to discern whether a match-mismatch between style and learning experiences improved learning.<br><br>A key use of the instrument was to help students become more independent in their learning, once they were aware of their style. |
| *Canfield Learning Style Inventory*<br><br>Scales in four areas:<br>1. conditions of learning<br>2. content preferences<br>3. mode preferences<br>4. grade expectations<br>(Canfield, 1980) | This model was also a comprehensive test.<br><br>Conditions of learning encompassed need to affiliate with others, structure, achievement and orientation towards authority and competition.<br><br>Content embraced numerics(numbers and logic), qualitative (words or language), inanimate (things) and people.<br><br>Mode was listening, reading, iconic and direct experience. |

*Table 2.5: Some Instructional Preference Models of Learning Styles (Claxton and Murrell, 1987, pp 46-53)*

These Instructional Preference models of learning style attempt to incorporate many different factors in a broad spectrum approach, which cuts across former models. These instruments measure student attitudes, rather than actual behaviour. As Claxton (1990) points out, there can be a considerable difference between espoused theories and theories in action.

When students are placed in a group learning situation in the classroom, each individual has to deal not only with the way any lesson content is presented, but also with the nature and structure of that content, the social interactions within the class, and the nature of the task which determines expected performance. Any one or a number of these aspects of the classroom environment may cause the student concern. Many different things may be learnt which integrate affective, cognitive and psychomotor domains. Evaluation which is focused on the measurement of standardised performance skills in one domain will fail to indicate the depth and breadth of student learning, and will fail to acknowledge the situated nature of learning (Brown, Collins and Duguid, 1989).

Research on learning styles deals with many aspects of the individual, as there are many ways of looking at the individual in a *learning* situation. The plethora of models should not be seen as evidence of a discipline which lacks theoretical focus, but as a positive sign that many in that discipline share the same idea but view it from their unique perspective. It points to the richness of variables in a living system (the learning human) which is evolving on both the individual and collective level with each advance in understanding of how we learn.

What is distinct about the learning process as opposed to genetic inheritance of physical characteristics is the ability to change within the one lifetime. The core facilitator of such growth may be self-awareness and knowledge of individual differences in the intake, processing and output of information. The more factors which can be acknowledged in the analysis of a complex system, the more people who can be reached via their current dominant perspective.

The greatest comfort and boost to self-esteem may come from knowledge that others are like you. The realisation that there are alternate ways to do things, that change is possible, and that change can also be beneficial, provides the gift of choice. Kolb (1984) links learning with personal growth in the experiential learning model. This shifts the emphasis which society places on the need to learn from short term job preparation to a lifelong quest for personal growth, which may lead the individual through a range of jobs. What was once seen as inability to remain with one position or profession can now be viewed positively as personal growth and experience.

With employer demands for flexible workers in times of rapid change, particularly where technological innovation has removed the basic manipulative or administrative chores, the workers need to know how to develop that flexibility which accompanies higher order thinking (Slovin and Woolf, 1989). That means they need to know how they can change, not only in the content of their knowledge, but in the way they view and apply that knowledge. It seems quite logical to expect a mechanic to know all about an engine to get the best performance from it, yet the learner is frequently not informed about the many ways to tune their mental engines. Awareness of the diversity of learning styles and associated strategies provides a good start.

### *Motivation*

The more comprehensive models of learning style simply tell us what we already know—that the learner is an incredibly complex entity. Motivation appears in models of learning styles as they are arranged by Claxton and Murrell (1987) at the level of social interaction. When you bring a group of people together for the prime purpose of learning, this factor called motivation is often singled out as the driving force behind the action or inaction of the learner.

Entwistle (1987) describes the progression in acknowledged motivational factors from extrinsic and intrinsic cognitive rewards through to the inclusion by Kozéki (cited by Entwistle, 1987) of affective and moral dimensions of motivation. The combination of cognitive motivation with affective or moral dimensions is recommended by Kozéki for the development of students with a rounded personality.

Entwistle notes that motivation is not a stable characteristic in students, and it is directly influenced by parents, peers and teachers. Motivation is related to the student's approach to learning, as indicated in *Table 2.6*:

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*Table 2.6 : Motivation and Approaches to Learning (Entwistle, 1987, p69)*

Student intentions in the learning situation are very important, especially if they are to engage in any form of self-regulation.

## ***Self-Regulation***

Learning can occur at any time or place, and certainly does not require a classroom. When the concept of self-regulation is applied to learning, it is usually equated with an academic context:

> *"As an organising concept, self-regulated learning describes how learners cognitively, motivationally, and behaviourally promote their own academic achievement." (Zimmerman & Schunk , 1989 - preface)*

Zimmerman (1989) looks at models of self-regulated learning and academic achievement. Self-regulation theories are described as a distinctive approach to academic learning and instruction, and are compared across answers to the following questions:

> *"1. What motivates students to self-regulate during learning?*
>
> *2. Through what process or procedure do students become self-reactive or self-aware?*
>
> *3. What are the key processes or responses that self-regulated students use to attain their academic goals?*
>
> *4. How does the social and physical environment affect self-regulated learning?*
>
> *5. How does each learner acquire the capacity to self-regulate when learning?" (Zimmerman, 1989, p6)*

Six theories — operant, phenomenological, social cognitive, volitional, Vygotskian, and cognitive constructivist, are reviewed. They all assume that students :

> *"(1) can personally improve their ability to learn through selective use of metacognitive and motivational strategies*
>
> *(2) can proactively select, structure, and even create advantageous learning environments; and*
>
> *(3) can play a significant role in choosing the form and amount of instruction they need." (Zimmerman , 1989, p4)*

The appeal of the theories to educators is seen as their ability to explain student motivation as well as learning. Several reasons are put forward for why students self-regulate some things and not others. Firstly, they don't believe that a known self-regulation process will work, is needed, or is preferable in a particular learning context. Secondly, they may not believe that they can successfully execute an otherwise effective self-regulation response. Thirdly, students may not be sufficiently desirous of a particular learning goal or outcome to be motivated to self-regulate.

Paris and Byrnes (1989) present the constructivist theory of self-regulated learning as the orchestration of self-competence (what you know) and performance factors (how you use that). The following six principles are identified as common historical themes to constructivism (Paris & Byrnes, 1989, pp 171-173):

- there is an intrinsic motivation to seek information— the learner is active, not just responsive
- understanding goes beyond the information give— people impose order on their perceptions, and generalise their actions to other situations
- mental representations change with development— from sensorimotor to symbol and imagery, then linguistic through to abstract logic and graphic illustrations.
- there are progressive refinements in levels of understanding— understanding is never final, as there is constant equilibration between current knowledge and new input. Progressive refinements can be initiated by reflection, experience, social guidance or new data.
- there are developmental constraints on learning— thresholds for learning are based on previous knowledge and experience.
- reflection and reconstruction stimulate learning— the primary emphasis is placed upon intrinsic motivation to re-examine one's self, behaviour and knowledge. Reflection develops from autonomous self-correcting behaviour and internalised feedback from others. Students begin to ask questions of themselves, about their successes and failures

Paris and Byrnes (1989) see children as scientists, who construct theories of their academic competence, effort, tasks and strategies. As these four component theories are progressively refined and integrated, they emerge as an overarching theory of self-regulated learning:

*Academic competence* : Children's concepts of competence move from effort to social comparison, grades and normative feedback.

*Effort* : As ability and effort are distinguished, there are many opportunities to form distorted concepts of effort, such as learned helplessness (no point trying as I'll fail anyway), or that teacher help equates with low ability.

*Tasks* : The academic tasks and evaluation methods encountered at school help shape the theory of tasks. If the goal of work is "task-involved" for mastery and understanding, rather than "ego-involved" for competition and comparison, then tasks can be internally motivating. Alternately, a theory of tasks as work-to-be-accomplished circumvents rather than promotes learning. Familiarity with task structures such as worksheets leads to transfer of procedures, which may or may not be appropriate in more complex tasks.

*Strategies* : A wide variety of strategies can be facilitated through cognitive development, practice with academic tasks and specific instruction. Children may possess declarative and procedural knowledge of strategies, but the conditional knowledge of when and why strategies are effective may be fundamental to spontaneous transfer of their use.

To support the development of a theory of self-regulated learning in students, a classroom environment should offer instruction which meets and extends each individual. Three instructional techniques which offer such opportunity are peer tutoring with dialogue, the direct teaching of strategies together with their application and cooperative learning (Paris & Byrnes, 1989).

Self-regulation is a characteristic of a learner which permits the teacher to structure learning tasks in such a way that the learner is given more freedom to select resources, monitor progress and manage the learning process. The nature of the tasks will vary according to another learner characteristic— that of relative expertise.

### Expertise

As with many concepts, "expertise" has a number of specific meanings, depending on the source of literature which you access. An extremely liberal view of expertise permits the use of the term for content and/or process— the content expert on cricket history may be a walking encyclopedia of cricketing facts spanning the last 60 years, but he/she may not necessarily demonstrate higher order thinking skills.

Cox and Cumming (1990) differentiate between expertise and skilled performance. Experts typically classify problems on the basis of deep structures and underlying principles, reason about a domain from first principles by running mental simulations, and chunk information in larger units than novices.

According to Spiro, Feltovich, Jacobsen and Coulson (1991) students can fail to reach the stage of advanced knowledge acquisition in an ill-structured domain such as medicine or literature, due to the problem of oversimplification— of content, learning strategies and evaluation. Ill-structured knowledge domains exhibit conceptual complexity within a case or situation, and irregularity across cases or situations. Cognitive Flexibility Theory emphasises the flexible use of pre-existing knowledge, and makes specific recommendations about multiple approaches that range from multiple organisational schemas for presenting subject matter in instruction, to multiple representations of knowledge. The *criss-crossed landscape* is the metaphor employed for multi dimensional traversal of complex subject matter.

Gott (1990) isolates strategic knowledge as the difference between novice and expert performance. Focus is placed on strategic control processes such as planning, knowledge deployment, and performance control and monitoring:

> *"A strategy establishes the general plan (or approach or goal structure) that guides the solver through the problem space." (Gott, 1990, p173)*

The required strategic control skills are often ignored in traditional instructional programs, so strategic knowledge can only be acquired in that case through problem-solving experience. Once acquired, the experienced performer's strategies tend to become compiled and tacit, and thus are not made explicit for other learners. Gott (1990) also recognises that expertise is inversely proportional to the level of external support needed for task performance.

In the school setting, expertise is a relative concept— the talented student is an expert when compared with his/her peers. The NSW Department of School Education Policy for the Education of Gifted and Talented Students (1991) defines gifted students as those with the potential to exhibit superior performance across a range of areas of endeavour, and talented students as those with the potential to exhibit superior performance in one area of endeavour.

Other descriptions of gifted and talented students are provided by the NSW Department of School Education (Braggett, 1991) for teachers to appreciate the strengths and weaknesses of a range of perceptions of talent. The traits of Renzulli's three-ringed model are above average ability, task commitment and creativity. The model of Klaus Urban adds divergent thinking (fluency; flexibility; originality; elaboration), tolerance of ambiguity (risk taking; openness to experiences; humour; adaptation) and motives (curiosity; playfulness; self-actualisation).

The six areas of talent identified by the NSW Department of School Education (1991) are social and leadership ability, creative or productive thinking, specific academic aptitude, visual and performing arts, psychomotor ability and creative intellectual ability. The recommended classroom management strategies (Braggett, 1991) for gifted and talented students include :

- an open, accepting, independent, mobile, complex and student-centred learning environment

- a content approach with variety in depth and breadth, a degree of abstraction of concepts, opportunity to study personal career and social characteristics of individuals and a range and variety of inquiry methods
- thinking processes such as open-ended questions, expression of logic and reasoning, flexible topic choice and method of study, varied strategies and group interaction activities to provide social and leadership skills
- the end products—students should transform rather than summarise information, and deal with real problems or relevant issues
- the cooperative learning— students should be taught cooperative skills, given group goals, encouraged to peer tutor and use cooperative language
- the contracts and management plans— students should be taught the skills of resource and time management, and self-assessment
- the negotiated learning— students should be set clear parameters, made aware of possible options and involved in assessment negotiation
- the learning centres— routines should be established for these centres, to which students ought to contribute

The broad concept of expertise encompasses the school interpretation of superior performance relative to peers in single or multiple talent streams. This performance involves integrated content and process. The acquisition of advanced knowledge in an ill-structured domain requires the ability to compile information in a flexible manner in response to a unique problem. The course of action is not known prior to knowledge use, and can't be pre-specified. Such breadth and depth of knowledge is obtained by repeated criss-crossing of a complex knowledge landscape via alternate knowledge representations and multiple problem scenarios. Expertise is not something attained without considerable effort and experience, though the gifted and talented student may be able to acquire knowledge more rapidly than peers.

As Gott (1990) noted, the practices of the expert may become automated and therefore covert. Without sharing of process strategies en route to development of expertise, less students are likely to reach the stage of expertise which allows them to orchestrate unique collections of material and creatively test the sort of novel strategies required in a new situation.

In terms of the classroom model constructed in *Figure 2.1*, we have discussed in some depth the constructivist teaching/learning philosophy, rigid curriculum derived needs of the learner in terms of the knowledge construct, and some of the many characteristics of the learner which can and should influence classroom practice. The blend of these three factors already permits extremely varied classroom practice, when one or another factor dominates the teacher's perspective.

Philosophy will influence in a global way how the teacher wishes to set up the learning environment. Curriculum provides specific learner needs in terms of knowledge, skills and attitudes. The context and relevance of this knowledge is usually absent from the curriculum, and is left as an overlay which the dedicated teacher has to provide, in order to stimulate deep processing and promote in students the desire to engage in conceptual change learning. When a teacher is also armed with a broad knowledge of learning styles, it potentially alters the way they view their role and the way they prepare for a class. Three extreme teacher perspectives illustrated below suggest variations in teaching approaches with consideration of just three classroom factors:

- A teacher with a non-constructivist content perspective, who regards content transmission as their dominant role, usually applies their content expertise to the organisation of information in a logical sequence within a hierarchy. This information is often detached from application and context. Emphasis is placed on sequence, memory, learning strategies, objective outcomes and tests.

- A teacher with an application perspective, who regards life skills preparation as their dominant role, combines content and relevant socially derived skills in a range of specific problem solving contexts. Short term skill training may tailor students very precisely for particular tasks, but transfer of skills requires their application to numerous different situations.

- A teacher with a learning style perspective, who regards lesson preparation for a diversity of learners as their dominant role, is faced not only with a multiplicity of ways of knowing the content, but also with many ways of using that content. The teacher is forced to ask the additional question - what *might* the learner want to do with this knowledge? They might need to expand on it, analyse it to formulate a theoretical framework, apply it to a practical situation or be able to recognise when it is relevant. A teacher thinking along these divergent lines is open to pattern recognition of generic learning strategies, as well as those which are content or discipline specific. They can also ask the students to select tasks.

Teachers have to reconcile their implicit theories of the classroom (Claxton, 1990) with the curriculum and the characteristics of their group of learners. One of the practical factors in the iterative design of classroom learning tasks is the nature and availability of appropriate resources.

### 2.2.4 Available Resources

Resources may be thought of in three main categories— human, material and perhaps the most precious of all—time.

Human resources provide content knowledge, practical application and relevance, shared experiences, discussion and strategy modelling, listening and co-learning. When the teacher is considered a co-learner in a constructivist classroom, anyone can be both a teacher and a learner. One of the most neglected human resources is the student group themselves. In the words of Anderson (1994):

> *"Teaching our students to be teachers themselves will also help remind us, and them, that the best way to learn something is to try teaching it to someone else, and that students themselves are a greatly under-used resource for teaching." (Anderson, 1994, p112)*

The availability of additional human resources often shapes the nature of possible learning tasks, via such teacher generated questions as:

- Is team teaching an option?
- Is a guest speaker/expert available to model and set an authentic task?
- Is there an excursion which would provide context and relevance?
- Are there mentors/experts available for the students to access for support with on-going personally meaningful tasks?
- Can I set a task which will be relevant to the student's family and thus possibly receive guidance and support?

Materials may include a broad range of tangible objects which befit the subject, such as concrete examples or working models, plus a range of media resources, in formats to suit print, video, audio and computer delivery. An interesting media debate continues between those who support a relationship between media and learning, such as Kozma (1994), and those who suggest the significant factor is instructional method, such as Clark (1994).

Clark (1994) reiterates a hypothesis made a decade earlier that media do not influence learning, but are merely the delivery vehicle for content:

> *"I accept the point that whenever learning occurs, some medium or mix of media must be present to deliver instruction. However, if learning occurs as a result of exposure to any media, the learning is caused by the instructional method*

*embedded in the media presentation. Method is the inclusion of one of a number of possible representations of a cognitive process or strategy that is necessary for learning but which students cannot or will not provide for themselves." (Clark, 1994, p26)*

Clark feels the integration of media attributes (the surface features of learning systems) with the more structural and necessary "active ingredient"—instructional method, simply confounds media attribute studies. He suggests "it is important to derive media that are capable of delivering method at the least expensive rate and in the speediest fashion."

Kozma (1994) reframes the debate to consider the capabilities of media, and the methods that employ them, as they interact with the cognitive and social processes by which knowledge is constructed. Past failure to link media and learning is attributed to a behavioural view of media as stimuli to which the learner may respond. Kozma asks that we consider the question :

*"In what ways can we use the capabilities of media to influence learning for particular students, tasks and situations?" (Kozma, 1994, p18)*

Jonassen, Campbell and Davidson (1994) agree with Clark (1994) that media are substitutable and ephemeral, and also with Kozma (1994) that "media are synergistic combinations of technology, task and context." They suggest that attention should be turned to the learner, in the light of constructivist learning theory. They recommend a re-focus on the role of media in supporting rather than controlling the learning process, and conclude:

*"That the more important debate is not about the relative efficacy of instructional components as much as it is the role of the learner and the context of learning." (Jonassen, Campbell and Davidson, 1994, p32).*

Jonassen, Campbell and Davidson (1994) emphasise the need to consider the context of media use and the distributed nature of intelligence:

*"manifest in activity and distributed between learners, the activity they are engaged in, the tools they use, the community of scholars they work in, and the discoveries of scholars in the past." (Pea, cited by Jonassen, Campbell and Davidson, 1994, p33)*

The emphasis is on the effects of learning *with* accompanying media, rather than the assumption that learning occurs as a result *of* media use. Any teacher who has spent hours preparing resource material knows that there is far more to learning in the classroom than the nature of resources which you provide. The same resource material will be used very differently:

- by different groups which vary in terms of learner characteristics
- by similar groups of learners arranged in collaborative or cooperative tasks
- by similar groups asked to perform different tasks
- by similar groups allowed access to additional resources
- by similar groups performing the same task with the same resource bank but allowed different amounts of time

This list of situations is short but emphasises what the teacher intuitively knows about resource material— that there are many factors which will modify the potential benefits of resources, according to the overall context of their use. Time and the pressures which lack of time place on the learning process is one of the important factors.

Time restricts or opens up opportunities for deep processing, collaborative work and long term goals. The students need time to reflect on material they have used, to discuss their ideas and challenge the ideas of others, and to communicate those ideas not only in verbal but also in graphic and kinaesthetic ways to promote creativity and achieve personally meaningful goals.

The flexibility required to allow for differing rates of student processing means that the teacher has to be prepared to change plans at any stage, and must focus heavily on monitoring of student activity, coordination of different groups, and reflection of student findings back to the whole group.

The availability of human resources, such as student family support, has a considerable influence on the structuring of classroom time, and the amount of home time a teacher can request from students. Time is a significant factor in determining the nature of learning tasks.

### *2.2.5 Learning Tasks*

Learning tasks represent a point of convergence. All the preceding factors plus the curriculum evaluation requirements influence the teacher and guide his/her subsequent selection or design of classroom learning tasks, which are the interface between the education system and the learner. In a form of role play, the potential classroom action is anticipated by the teacher, and numerous scenarios are proposed. The influence of the curriculum evaluation requirements must be acknowledged before creative freedom can allow for the needs of students as individuals.

Dunn and Larson (1990) incorporate aspects of cooperative learning, a whole language approach to literacy, and inquiry-based approaches in maths and science to their description of strategies for approaching design technology. When considering challenges for children, they place the problem along an open to closed continuum according to the profile of responses to a number of key questions, which are shown in *Table 2.7:*

| *Open* | | *Closed* |
|---|---|---|
| | • *What is the context of the task?* | |
| Natural childhood context | Child-centred topic work | School-based curriculum |
| | • *Who sets the challenge?* | |
| Child-identified | Child-selected from a range of given options or negotiated with the teacher | Teacher-identified |
| | • *What materials and tools are available?* | |
| Wide range of choice | Some selection | Limited range |
| | • *Who selects the materials?* | |
| Child-centred | Negotiation based on need, availability, and substitution | Teacher-selected |
| | • *What form will the result take?* | |
| Child-designed | Variations on a pattern | Pattern |
| | • *What steps will be taken?* | |
| Discovered | Guided | Direct instruction |
| | • *Who sets the criteria for the challenge?* | |
| Child | Negotiated between child and teacher | Teacher |
| | • *Who evaluates the process and result?* | |
| Child | Child-teacher partnership | Teacher |
| | • *How much time is available?* | |
| Determined by child | Negotiated according to task, child's needs, and availability | Prescribed time unit |

*Table 2.7: Design Technology Challenges on an Open-Closed Continuum (Dunn and Larson, 1990, pp 124-125)*

Problems at the open end of the continuum of Dunn and Larson approach the goal-directed learning described by Schank and Cleary (1995). This is based on the process of natural learning— the learning waterfall:

> *"Adopt a Goal*
> *Generate a Question*
> *Develop an Answer" (Schank and Cleary, 1995, p68)*

The student sets a goal in which he/she is interested and is prepared to try things out. Sometimes he/she fails. The questions prompted by this prepare the student to seek the answers. Schools tend to reverse this natural order, particularly with the selection of closed activities. Teachers tend to teach skills before actions, actions before goals, and generalisations before experience (Schank and Cleary, 1995).

Brown, Collins and Duguid (1989) discuss the transfer of authentic activities (ordinary practices of the culture) to the classroom. This transfer immediately alters the context of the activity. Testing is introduced, and "success within this culture often has little bearing on performance elsewhere." When teachers aim to create classroom tasks, they often dismiss apparently peripheral features of task context which give the task authenticity. In addition, students may come to rely on features of the classroom context which are not part of the authentic environment. Much of what is learned in classes may never apply outside the classroom.

For the teacher wishing to provide greater student choice in the range of tasks, one possibility is to introduce the task in home-based and group assignments. For home-based work, the student may receive varied family support. This obviates the need to model and help students develop their metacognitive skills. Where there can be no home assistance assumed, creative tasks are usually organised in class groups. The nature of the task which the individual performs depends largely on the nature of the group process requested by the teacher—whether small group, collaborative or cooperative.

### *Cooperative/Collaborative Learning Tasks*

The term collaborative learning is occasionally used as an umbrella term to encompass cooperative learning and small group work. Chung (1991) defines these three terms separately as follows:

- small group - is the reduction in the size of groups, in order for teachers to make their work less complex

- cooperation - the antithesis of competition - means to help each other to achieve a single group outcome
- collaboration - the antithesis of individualisation - refers to the more humanistic relations in the classroom in order that learners become more active, autonomous and self-responsible

The terms collaboration and cooperation are usually viewed quite separately by others. Each term implies grouping, but they lead to different outcomes. Steeples (1993) explores the relationship between learner collaboration and learner independence within electronic learning environments which are aimed at supporting adult learners in professional development. Collaboration — the pooling of ideas with individual output, offers a number of benefits:

- It supports and encourages the sharing of individual expertise and experience.
- The articulation of an individual viewpoint with feedback from other perspectives can lead to a deeper understanding and improved metacognitive skills of reflection and refinement.
- Active knowledge construction and engagement are promoted.
- Group involvement and identification support sociological needs of interaction.
- Participants are active.
- Articulation and refinement can lead to a generalisation of underlying principles and facilitate transfer to a broader context.

According to Whipple (cited by Chung, 1991, p17) the beneficial features of collaborative learning in the classroom are that:

- teachers and learners are active participants in the educational process
- collaboration reduces the gap between teachers and learners
- collaboration creates a sense of community
- knowledge is created, not transferred
- collaboration locates knowledge in the community rather than the individual
- collaboration makes teaching and research related activities

Johnson and Johnson (1993) describe cooperation as working together to accomplish shared goals. They discuss three possible types of student-student interaction— competitive, individual or cooperative:

- Competitive interaction is based on a negative interdependence of goal achievements —it involves a winner and therefore a loser. Evaluation is on a norm-referenced basis.
- Individual student work is based on independent learner goals and assessed on a criteria-referenced basis.
- Cooperative interaction is based on positive interdependence of goal attainments. The whole group sinks or swims together.

The five basic elements of cooperative learning are positive interdependence (achieved by assigning roles), face-to-face promotive interaction (encouraged by discussion and peer tutoring), individual accountability (fostered by individual testing then random selection), social skills (leadership, communication, decision-making, conflict management and trust building) and awareness and support of the group process (reflection and comment on ways to improve the group process). Johnson and Johnson (1993) feel that the positive interdependence of this cooperative learning arrangement is what facilitates student receptiveness to feedback from the teacher and peers. The outcomes of cooperative working are higher achievement and greater productivity than working alone:

> *"The more conceptual the task, the more problem solving required, the more desirable higher-level reasoning and critical thinking, the more creativity required, and the greater the application required of what is being learned to the real world, the greater the superiority of cooperative over competitive or individualistic efforts." (Johnson and Johnson, 1993, p143)*

Johnson and Johnson (1993) are quick to point out that cooperative learning is not putting students into groups, having students discuss an individual task, or asking those students who finish first to help the others. The distinction between the outcomes of cooperative and collaborative learning is an important one, yet cooperation is important for the development of independence required for successful collaboration:

> *"The more individuals work cooperatively with others, the more they see themselves as worthwhile and as having value, the greater their productivity, the greater their acceptance and support of others, and the more autonomous and independent they tend to be. Cooperative experiences are not a luxury: they are an absolute necessity for the healthy development of individuals who can function independently. " (Johnson and Johnson, 1993, p144)*

Once students are involved in learning tasks, the teacher's role is to provide ongoing support and guidance. This is achieved through the use of a range of interpersonal support tools.

### *2.2.6 Support Tools*

### *Metacognition*

Paris & Winograd (1990) define metacognition as knowledge about cognitive states and abilities that can be shared among individuals, including the affective and motivational aspects of thinking. Two aspects of cognitive states, self-appraisal and self-management, are particularly important.

- Cognitive self-appraisal (how people act on what they say is important) can be declarative (what you know), procedural (how you think) and conditional (when and how you think).
- Cognitive self-management (what people say they'll do and their actions) is the way metacognition helps to orchestrate cognitive aspects of problem solving. Students form good plans, use a variety of strategies and monitor and revise ongoing performance. In short they are evaluating, planning and regulating .

Metacognition should be regarded as an intermediate step to proficiency, embedded in ongoing thinking and problem-solving. It is particularly important for new knowledge mastery, trouble shooting with awareness of strategies, and initial teaching of skills . The metaphor of cognitive tools is consistent with the ideas of Vygotsky (1978). Good craftsmen use tools wisely and independently.

Self-appraisal is not devoid of affect. Many decisions are underpinned by how learners feel, hence you can't separate motivational aspects from cognitive knowledge. The results of self-appraisal lead to decisions on self-management.

The term metacognition is used freely in the literature but often without a clear understanding of its meaning. In their interpretation of the knowledge construct, Alexander, Schallert, & Hare (1991) omit the shared aspect in the definition of Paris and Winograd (1990) and discuss metacognitive knowledge (see *Figure 2.4*) as a theoretical construct with three components—self-knowledge, task knowledge, and strategic knowledge. This is in keeping with their presentation of knowledge, not the functional aspects of thinking and learning.

Other writers view metacognition as a procedural skill, with alternate names such as self-regulation, autonomous learning, and meta-reasoning (Eylon & Linn, 1988), as a link with Schema Theory (Anstey, 1988) or incorporating metamemory. metacomprehension, self-regulation, schema training and transfer (Osman & Hannafin. 1992). Some of these terms are defined below:

- Metamemory includes awareness of different memory strategies and when and how to use them.
- Metacomprehension is knowing about comprehension and how to comprehend. Comprehension failure must be recognised and repair strategies implemented.
- Self-Regulation is continuous metacognitive adjustments by learners in response to feedback on errors. It is not good for the learner to rely solely on external prompts — they should learn to question strategies themselves without prompting.
- Schema Training involves the construction of conceptual frameworks which assist comprehension.
- Transfer is the application of a strategy to dissimilar tasks, problems or circumstances. Transfer is near if the problem is similar, and far if the problem is dissimilar. Another terminology refers to "low-road" transfer as detail and low-level knowledge, while "high-road" transfer emphasises relational, conceptual knowledge.

Borkowski et al (1990) suggest that learners who feel good about themselves and their ability — who are intrinsically motivated to learn and who have effort-related attributions (ie. more work equals more gain) — are more likely to believe in strategic behaviour and to develop complex, mature strategy knowledge. External control attribution beliefs (ie. others determine your fate regardless of personal effort) undermine intrinsic motivation (ie. why bother — others set the agenda anyway). Self constructs (how you view and feel about yourself) drive metacognitive approaches by giving learners reasons to learn. Effort related attributions (ie. more work equals more gain) are of little use if learners "spin their wheels", not knowing what strategies should be used to continue. Hence internal "locus of control" is more likely to support the development of a range of metacognitive strategies and result in improved performance (Borkowski et al, 1990).

### *Metacognition as a Learner Variable or Outcome*

In a synthesis of research on all variables which can be related to learning, Wang, Haertel, & Walberg (1990) isolate 30 variables within six categories. Within the Student category, the metacognitive items emerge as the most important: they include comprehension monitoring, use of self-regulatory, self-control strategies and the use of strategies to facilitate generalisation of concepts. Perseverance on learning tasks and motivation for continual learning are also important student items. They recommend that students should be trained in metacognitive strategies.

Eylon & Linn (1988) review research on the learner and learning from a differential perspective. They seek to use intellectual and psychosocial variables to explain learner performance in a subject. The typical intellectual variables include factual knowledge (crystallised ability) and abstract reasoning (fluid ability). There is a recent expansion of the intellectual variables to include self-regulation and metacognitive skills which support effective lifelong learning. Attempts to measure metacognitive reasoning fail as metacognitive reasoning is confounded with domain-specific knowledge.

If we view metacognition as something each of us has in a measurable dose, something that reflects our ability to learn, and something which can be used to predict our future performance, then the construct is of little value. Rather, metacognition is about knowledge, skills, judgements of task difficulty, estimates of effort required, beliefs about ability, worth of strategies, use of failure, and the purpose for performing a task. All these guide learner decisions on task choice, the effort they will expend and the strategies chosen (Paris & Winograd, 1990). In these ways metacognition, a multi dimensional construct, firmly underpins learning. Metacognitive support should be affective, motivational and strategy-based, its goal the improvement of learning and performance generally.

The concept of metacognition has some persistent problems with its fuzzy definition — can metacognition occur unconsciously or must it be conscious? How can we compare novice and expert if the expert's strategies are tacit? The construct can't have explanatory power and we can't prescribe techniques if we don't understand exactly how it helps learning (Paris & Winograd, 1990). Likewise it does not have any predictive value. A successful learner in one knowledge domain may be transferred or promoted to another domain. The underlying assumption is that the problem–solving strategies exhibited in the first domain will automatically transfer to the second domain. While it is beneficial to learn a range of concepts within one context or knowledge domain, it does not follow that all those concepts will be transferred to the new situation with equal success (Bransford, Vye, Kinzer, & Risko, 1990).

Within the conceptual framework of knowledge proposed by Alexander, Schallert and Hare (1991), the acquisition of knowledge in one form does not automatically guarantee another form. In many instances we know the "what" without the "how" and "when".

Specific knowledge is required to solve problems, but that knowledge must also be spontaneously accessible, rather than inert. Frequently, people need to be reminded of what they already know. They can supply facts when asked, but they don't spontaneously use them in problem solving. Knowledge of general strategies can remain just as inert unless people are specifically prompted to try them. Conditional knowledge associates with the knowledge, the circumstances in which it is applicable (Bransford et al, 1990). Strategies should therefore be taught together with varied examples of their application.

### *Cognitive Strategies*

Schmeck (1988) describes strategies and tactics as the conscious decision to implement skills— which are the things we can do. Strategies and tactics involve plans, which can be understood from the perspective of motives. Failure of a student to carry out a particular activity does not imply they don't have the skill— they may not see the point in using it.

In a learning situation, two key sources of influence on behaviour are characteristics of the *person*, and the specific *situation*. To the constructivist, it is not necessary to separate these two, but they do provide possible avenues of improvement in education:

- Re-structuring the situation to alter student perceptions
- Focus on development of the person's skills through cognitive and emotional development

The teacher can control many aspects of the classroom environment which will alter how students perceive that environment, and they can encourage the development of personal strengths and varied learning strategies.

Derry (1990) directs attention to the educational goal of acquiring higher order thinking skills to access and apply facts and procedures to meaningful problems. Those who wish to promote general reasoning skills are encouraged to pay careful attention to the structure of declarative knowledge such that it remains accessible, not inert. Procedural skills will be accessed and used spontaneously if they have evolved through practice, and conditions for use are also understood. Derry goes on to concentrate on *learning strategies*, which are seen as the application of one or more specific learning tactic to a particular problem. The *strategy* is a complex plan formulated to accomplish a goal, whereas the *tactic* is any single processing technique used to service the plan. Learning strategies constructed by the teacher can improve general thinking skills in the classroom by:

• providing tools to encode information, and

• increasing metacognitive knowledge through teacher feedback on strategy use.

A clear distinction is made between learning strategies to support declarative knowledge ( organised collections of facts and concepts) and procedural skills (performance capabilities involving symbol manipulation). Ways to promote autonomous learning are also explored.

Declarative knowledge is of value if recalled when needed. Meaningful learning proceeds in working memory by connecting new ideas to prior knowledge, and is facilitated if additional ideas are generated by the combination— known as *elaboration*. This provides additional recall cues. The knowledge also needs to be well organised. Learning tactics which can be used in strategies to acquire declarative knowledge include:

• attention focusing (highlighting or underlining)

• structured focusing (look for headings, teacher-directed signalling)

• schema building (networking), and

• elaboration techniques (imaging, analogies)

Elaboration tactics such as self-questioning and image generating can be incorporated into schema-based learning strategies. Derry cites the questioning strategy used by Wittrock (1984) which requires students to think about passages in terms of "Who? What? Why? Where? When? and How?" schema, also generating passage summaries based on those questions.

Procedural knowledge activation results in operations on and transformations of information. Procedural skills when well learned can be activated automatically, unlike the conscious use of declarative knowledge. Procedural knowledge doesn't reside in *propositional* networks like declarative knowledge, but in an equally abstract conceptualisation called a *production*, composed of condition-action rules. Productions have an IF-clause (if such a pattern is recognised) and a THEN-clause (then a particular action is taken). Patterns activated in conscious working memory, recognised by a pattern-recognition production, signal an action-sequence production. Complex problems may link many productions to form a problem-solving strategy. In a problem solving situation, the relevant concepts will be recognised if they are known at classificatory or formal levels.

Action-sequence procedures are learnt in a slow process. Initial slow, conscious declarative representations transform into procedural encoding which can be combined to form complex automated actions. These are advantageous in that they free up memory, but disadvantageous if more flexible performance is required.

Less is known of strategies for acquiring useful procedural knowledge than declarative knowledge. To assist the learning of concepts, metacognitive knowledge in the form of rules and strategies for concept acquisition help encourage higher levels of conceptualising. Metacognitive knowledge also assists the acquisition of action-sequencing procedures, if students are encouraged to reflect on and analyse their performances as they learn, as long as they have an expert model. Derry (1990) advises that teachers can provide such performance models for students to emulate, but there is no substitute for extensive practice, which is better spaced over time.

In order to promote autonomous learning, several strategies are recommended:

- informed strategies training— teachers who devise, assign and explain learning strategies to students, and who give feedback on their use are already doing this
- fading prompts — metacognitive knowledge about when to use a strategy is a pre-requisite for self-regulated learning, so prompting should be faded
- general problem solving models so each learning task is analysed, and strategies devised, used and monitored. (Derry, 1990)

With more emphasis on teaching and sharing strategies, learning styles become quite significant. Certain strategies may relate to the acquisition of a particular kind of knowledge, but how the learner comes to understand that knowledge may depend on the many characteristics of learning style discussed earlier. In addition, while you may need to adopt a particular strategy in one job, an adaptation of that strategy may be required in future work. Without the flexibility to shift to another strategy, you are less able to grow with a job. Awareness of different strategies opens your mind to other ways of doing things, even if you are not comfortable with the strategy at this point in time.

The reality of work, family and recreation means the same individual may adopt many roles within a short period of time. Practical household problems call for the trial and error approach of the accommodator (Kolb, 1984), with no time for theory. The literature review you may have been set to write calls the assimilator to work, while assistance with ideas for a child's project summons the diverger. It is the converger who views the plans drawn up for household extensions and makes decisions on appropriate fittings. Many individuals will roam amongst these categories in everyday life. What is usually viewed as "learning" has an academic slant in schools, colleges and universities, or a practical slant in business, training and TAFE. The significant omission is personal learning — that which deals with everyday learning about relationships, society, the environment, personal development and work. That is the learning of most importance in a constructivist environment, as it views knowledge as an integrated whole from the learner's perspective.

What the learner needs following metacognitive support through strategy sharing and guidance in planning, monitoring and goal setting is vital feedback on performance.

### *Feedback*

Johnson and Johnson (1993, p135) regard feedback as "information made available to individuals that makes possible the comparison of actual performance with some standard of performance." At least three sources of feedback are available in a learning situation:

- oneself - personal feedback is intrinsic
- technology such as computers - can provide rapid feedback such as raw scores, percentage scores or numbers correct, and correct tutorial information in a multi dimensional and complex manner
- other people - interpersonal feedback - the most powerful and effective, since it is personalised, vivid, and can be sustained.

The cooperative group setting is considered ideal to combine all the above sources of feedback. This feedback affects the combination of procedural and conceptual learning required in modern technological settings, positive relationships and social support, social competencies and self-esteem.

The feedback provided by the teacher is just one level of many for the student. Within schools in the state of New South Wales, teacher feedback blends with feedback from:

- state level - how the student achieves in state wide examinations such as the English, Maths and Science competitions
- school level - how the student performs within their grade in a range of subjects
- class/subject level - this depends on the tasks and tone of the classroom — whether it is competitive, cooperative or collaborative
- task level - task variety will allow the student to gain feedback on content, processing skills, application skills and communication skills. If tasks require a variety of learning strategies, rounded academic development is more likely.

A vital aspect of support which bears little direct relationship to curriculum is feedback to students on their value as a person. That unconditional regard so prized for the development of internal motivation and self-regulated learning can be fostered directly by each teacher, and indirectly through class acceptance of a diversity of learning styles and support for individual differences. The ability of a teacher to promote an environment which supports such diversity is often constrained by curriculum requirements in terms of student evaluation.

## 2.3 The Shaping Role of Evaluation

Testing methods have a way of shaping the manner in which things are taught (Collins, 1990). There are three side effects of testing. First, learning and reasoning skills may be dropped in favour of simple skills which can be measured using a format such as the multiple-choice question (MCQ). This does not imply that all questions of MCQ format are simple. Second, testing encourages students to memorise rather than understand material. Third, the test-taking mentality predominates and drives many able and not–so–able students away from school and learning. With testing, while objectives can be specified and consistent standards achieved, the effects are too restrictive.

Schank and Cleary (1995) discuss the reversal of the natural learning process in classrooms:

> *"The answers are provided before the student has asked the questions.*
>
> *... This reversed process delivers education through a prerequisite-driven scheme in which curriculum planners demand that students initially learn basic things they feel those students will likely need to know later to do more advanced things. But two problems arise from this scheme. First, predicting which basic things different students will need to pursue their different interests is almost impossible. Second, it is almost impossibly boring for a student to learn basics when these basics are divorced from the context of something the student really wants to do." (Schank and Cleary, 1995, p5)*

They relate the crux of the problem to the testing process associated with fixed curricula. Objective tests suggest "right" answers, and teachers must dole these answers out. Since performance on standardised tests provides the basis of school evaluation, teachers are enticed to teach to the test, and students learn not to question or offer alternatives. The core solution, according to Schank and Cleary, is:

*"to eliminate competitive test scores... It is critical to recognize that the schools cannot be changed in any important sense until fixed curricula are eliminated. But fixed curricula will not be eliminated until we change the way we assess progress." (Schank and Cleary, 1995, p23)*

Jonassen (1991b) prompts debate about the problems of evaluation raised by constructivism:

*"Rather than attempting to map the structure of an external reality onto learners, constructivists recommend that we help them to construct meaningful and conceptually functional representations of the external world.*

*If learning outcomes are individually constructed, how do we evaluate them?" (Jonassen, 1991b, p29)*

Several guidelines are suggested:

- Authentic tasks with real-world relevance, that cross subject boundaries and provide different levels of complexity
- Knowledge construction, to a level where relevant problems could be solved, and a particular point of view developed and defended
- Focus on the process of knowledge acquisition, rather than the product— evaluation is then an integral part of the instruction process. The metacognitive awareness developed should also improve learning
- Evaluation should be context dependent— don't test with simplified, decontextualised problems
- Constructivist environments are most suited to the stage of advanced knowledge acquisition, where problems are complex, domain- or context-dependent problems
- Multiple perspectives in constructivism suggest multiple outcomes, and multiple evaluators— both novice and expert
- If products must be evaluated, then a portfolio of products should be evaluated. Multifaceted constructivist learning should allow different dimensions of learning to be represented in different products in different media
- Goals of learning could be negotiated
- Evaluation from a constructivist perspective should be less of a reinforcement and/or behaviour control tool and more of a self-analysis and meta-cognitive tool

The concluding remarks of Jonassen are haunting— educational goals stem from societal beliefs, which are at present objectivist. Society expects judgements to be made about performance and thinking. If we can't re conceptualise the outcomes of education from a societal perspective, to accept divergent points of view and alternative conceptions and processes, constructivist environments won't be implemented properly, and may, in fact, be a handicap to students.

## *2.4 The Teacher Role and Process Outcomes in a Constructivist Classroom*

The constructivist teacher has a facilitatory role, rather than a role as knowledge transmitter. Driver and Oldham (1986) present a model for a constructivist teaching sequence aimed at conceptual change in science education. This model is shown in *Figure 2.6* on the following page.

One important condition for the successful implementation of this sequence is sufficient time for students to share, reflect on, evaluate and re-structure their ideas, so the teacher has to be sensitive and value student ideas. Feedback from students to the teacher is vital, so the teacher can use this information to structure appropriate activities for subsequent lessons.

Reflexivity is very important for a constructivist approach. Orientation is aimed at motivation and relevance; elicitation encourages student expression of their ideas; restructuring involves a number of aspects, such as awareness of multiple perspectives, the need to evaluate alternatives, and exposure to expert views; application allows students to use their ideas in novel ways to extend the context; review asks students to look back at previous ideas to note how they have changed. Journal writing is an excellent technique to promote reflection and review.

A constructivist classroom can support the development of higher order thinking skills, problem solving skills and more self-regulated learners, however, this will continue to be constrained by the current testing or evaluation methods. These measure knowledge at the level of content and skills, but seldom tap into more general thinking skills and strategies. Setting loftier goals of higher order thinking means major adjustments to the assessment/evaluation process by which we determine student performance. This means the replacement of breadth with depth and relevance. Considerable time is required to adopt a classroom approach which supports student development of higher order thinking skills, student selection of goals, and activities which are provided within a rich cultural context.

Please see print copy fo image

*Figure 2.6: A constructivist teaching sequence (Driver and Oldham, 1986, p119)*

The above figure illustrates the kind of iterative and highly interactive teaching sequence which would be repeated many times in the classroom by a teacher with a constructivist view of learning— time and social acceptance permitting.

In contrast, *Figure 2.1* has presented the researcher's simplified model of some of the key classroom factors which currently influence and tightly constrain the way a teacher sets up the classroom environment.

The teacher's role according to society expectations is to implement a curriculum in terms of learning tasks to suit the needs of a specific group of learners, but only with reference to outcomes which can be evaluated by the current testing system. The teacher with a constructivist philosophy places a lot of emphasis on the individuality of their students, appreciates the varied knowledge and experience each one brings to the classroom, and understands that standardised curriculum outcomes and constructivism are incompatible. For such a teacher, it is often difficult to rationalise job demands with what they feel they should or could be doing for their students. Awareness of all the factors discussed in this chapter simply helps the constructivist teacher appreciate the enormous complexity of the classroom context, and the limited likelihood that they will be able to cater for many of the individual differences they perceive.

This chapter has touched at several points upon a rift that exists between the role which society imposes on teachers— driven by standardised tests, and the expectations that society has of teachers—their ability to produce knowledgable, collaborative, motivated and flexible workers. Brown, Collins and Duguid (1989) emphasise the uniqueness of the school culture created by the role imposed on teachers. Within this culture, much knowledge is decontextualised and abstract. Problem solving in this environment requires the development of strategies which may never apply to any work situation, and much school knowledge thus remains situated in the school context— swelling the ranks of inert knowledge.

The systemic approach to educational research (Salomon, cited by Kozma, 1994, p14) assumes that each classroom event has the potential to influence the classroom as a whole:

> *"These variables act on each other in interdependent ways. Changing one variable may have dramatic and perhaps unanticipated effects as it propagates through the complex web of relationships among variables in the system. The goal of this approach is to describe the pattern of relationships among a system of components and events as they interact and mutually define each other in real situations." (Kozma, 1994, p15)*

The following chapter discusses theoretically some significant alterations to a number of classroom factors prompted by the introduction of computers and educational software. The classroom teacher now has a hidden assistant—the software designer. The effects of this change are later examined in real situations through the classes.

# Chapter Three - The Addition of Computer-Mediated Technology

## Introduction

Developments in technology have been rapid. Multimedia capacity orchestrated by a computer has broadened the representational options through which individuals can express their ideas. Vast amounts of information can be readily updated, shared electronically over great distances, and re-organised as understanding develops. Rather than propagating a technocentric view of the technology, learning theorists are attempting to use the technology as a tool to facilitate learning strategies and allow for variations in learner style (Cognition and Technology Group at Vanderbilt, 1992; Rieber, 1993).

The educational software designer's theory of learning moulds the structure and functionality of their software (Rieber, 1993; Brown, Hedberg and Harper, 1994). Behaviourist and information processing models of learning focus very closely on task analysis, content and learning outcomes. These are defined early in the design process and can "contain" or restrict the learning experience. Constructivists acknowledge that you can set up a learning environment with its inherent conceptual schema and provide learner support tools to help learners assimilate information, acknowledging that the learner must construct his/her own knowledge and understanding. The outcomes are not predefined, as the learner's understanding will depend upon such factors as prior experience, knowledge and reason for information access. People learn best when they have an immediate need to know something in order to solve a problem (Schank and Cleary, 1995). Predefined pathways and explicit training in the use of metacognitive support tools are not necessarily a feature of this constructivist approach.

The growth in popularity of the student-centred learning environment and recent constructivist approaches to learning place responsibility for learning firmly on the shoulders of the learner. As a co-learner, the classroom teacher shares the burden and constructs a supportive environment full of meaningful tasks. When any of those tasks involves computer software, the educational software designer joins the classroom as a hidden co-teacher. The nature of the relationship between the teacher and software designer is very significant. For optimal effect, good communication between the teacher and designer helps ensure that their roles are collaborative and complementary, rather than disjointed and competitive. The classroom teacher is then free to adopt a range of roles, such as resource provider, manager, coach, researcher and facilitator.

From the learner's perspective in such a learner-centred environment, the responsibility may seem overwhelming—the learner may not possess the metacognitive skills required to make judgments and action choices without assistance (Perkins, 1991b). The teacher and designer can provide metacognitive support either in person, or through the use of cognitive tools, which can assist the learner to brainstorm, organise work, monitor performance and develop new strategies.

This chapter explores the influence of learning theory on educational software design, the effect of the resulting program style on the relationship between teacher and designer, and how all three players in the classroom—teacher, student and designer—can theoretically reflect, share strategies, and exchange perspectives in order for all to learn from the experience. The extra help in the classroom would not be possible without recent developments in technology.

## 3.1 Technology & One Toolmaker—The Educational Software Designer

Software techniques change to take advantage of improvements in hardware. People's use of computers changes as software caters more for what the user wants and needs (Messing, 1991). The concept of performance support has developed, whether performance equates with learning or job-related tasks. This concept extends the meaning of education throughout the workforce— a transition welcomed by the learner for its parallel with reality.

From an artificial intelligence perspective, Lawler & Yazdani (1987) describe two different approaches to the use of computers in education: Intelligent Tutoring Systems (ITS) and Computer-Based Learning Environments. Performance support systems incorporate aspects of both. They are electronic tools to facilitate performance. This may be accomplished through the structuring of a task, organisation of information, or manipulation of data.

Terms such as interactive multimedia, hypertext, hypermedia, nodes, links, and hypertext systems provide an indication of the type of structures commonly found in computer-based learning environments (Brown, Hedberg and Harper, 1994). It is easy to get sidetracked by terminology and lost in classification of software structures, but the key issue for education should centre on the learning processes induced by use of the software.

Jonassen (1991a) suggests the greatest potential of hypertext systems is their use as personal learning environments or cognitive learning tools in which cognitive strategies are embedded in application software. Some advantages of hypertext/hypermedia systems are the ease of information access across trails, the support for structuring and modularizing information, personalisation and annotation, the promotion of collaborative work and the production of simulations (Gluck, 1990; Heller, 1990). Some of the disadvantages are more informative — disorientation with your location, cognitive overload when following several trails or trying to remain oriented, flagging commitment and a poor presentation rhetoric or metaphor.

The technology now offers software designers the opportunity to develop a broad range of programs, in terms of structure, functionality, and multimedia capacity . Hannafin, Hannafin and Dalton (1993) note six major areas of improvement:

- adaptability
- realism
- hypermedia
- open-endedness
- manipulability
- flexibility

They regard flexibility as the greatest improvement in emerging technologies, leading to their integration across professionals who hold diverse views on the nature of learning and instruction.

The existence of software classification systems implies that there must be patterns of association between structure and functionality. Since the classroom setting is the venue for this study, then interest in the educational software designer can be directed through two key questions:

(1) What factors underpin and characterise a designer's style?

(2) How does that impact on the classroom?

The answers to such large questions can either be couched in very broad terms, or they can be discussed in terms of an encompassing paradigm. Squires and McDougall (1994) present such a paradigm— the Perspectives Interactions Paradigm.

The origins of this generative paradigm are important to place it in context. In responding to problems associated with use of a checklist approach to software *selection*, Squires and McDougall probe the theoretical frameworks beneath such lists and find a number of classification systems.

Three are reviewed:

- categorisation of software: these range from simplistic content-free versus subject-specific software, through to long lists which are detailed at the level of particular applications such as word processing or music composition. Criteria are often implicit, new categories are always appearing, and many programs cross category boundaries. Categories are geared to software designers.
- educational roles: one example cited is that of Taylor (1980)— computer as tutor (surrogate teacher) , tool (performs labour intensive activities) or tutee (computer is taught by learner who expresses ideas and solutions to problems). Squires and McDougall express the view that this framework of educational roles assumes the "scope and nature of the software environment defines educational possibilities." Therefore, roles are geared to designers, rather than teachers and learners.
- educational rationale: the framework of Kemmis, Atkin and Wright (1977) is cited as a very respected array of paradigms— instructional (mastery of content), revelatory (learning by discovery such as simulations), conjectural (development of understanding through the active construction of knowledge) and a free floating fourth, which cannot exist in isolation—emancipatory (use of data processing capabilities of the computer). The rationale approach suggests software is limited to one paradigm, and focus is placed on general curriculum issues and the teacher.

Since analysis is the process behind the development of a classification system, no single system can deal with the multiple perspectives which are required to understand a complex situation like the classroom. Squires and McDougall therefore move the emphasis away from *software attributes* to the broader *use* of software to enhance teaching and learning— through synthesis of a paradigm which places three actors on stage— teacher, designer and student (see *Figure 3.1*).

Interactions between the perspectives of the three actors are the key considerations:

- Student-Teacher interaction encompasses teacher roles, increased student responsibility, and classroom activities.
- Designer-Teacher interaction raises issues of curriculum content and process.
- Designer-Student interaction explores learning processes.

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*Figure 3.1 - The Basis of the Perspectives Interaction Paradigm— adapted from Squires and McDougall (1994) p67*

The only interaction which is bi-directional and thus active in this model is that between teacher and student, who interact directly in a social sense in real time. The relationships between designer and both teacher and student are different, as they are static. The designer perspective is expressed to both teacher and student in terms of implicit assumptions and intentions of the software design. The dotted lines which link both teacher and student back to designer are there to represent:

- the designer's mental model of the teacher or student's mental model of the program
- feedback on unintentional use of the software.

The first question left on hold has been answered by Squires and McDougall:

> *"The theory of learning that the designer has adopted as a basis for development of software is a critical aspect of software assessment. The views about learning underlying the design define the essential character of the interaction between the perspectives of the designer and the student." (Squires and McDougall, p 87)*

They differentiate behaviourist from constructivist design on the basis of three characteristics—learner control, complexity and challenges. This provides a simplistic look at an influence which deserves some close attention.

## 3.2 The Influence of Learning Theory on Educational Software Design

Instructional design is the process of creating the actual structure and form of the program. Behavourism, cognitive information processing and constructivism represent three views of learning theory which have heavily influenced the design of educational software.

### 3.2.1 The Influence of Behaviourism

Reinforcement theory is fundamental to behavioural psychology, which can be attributed to the work of B. F. Skinner (Skinner, 1968). Learning is viewed as the formation of conditioned stimulus-response associations. Computer-Based-Instruction (CBI), which is founded on these principles, characteristically presents the individual student with small lesson units in discrete, discernible, controlled steps. Pathways are usually directed and learning outcomes relate to specific objectives. Reinforcement is usually continuous rather than intermittent, while feedback generally gives an indication of the response accuracy. Most responses are multiple-choice or simple completion. Performance is measurable. Motivation is provided by the desire to seek stimuli and make responses leading to very positive consequences. The usual criticisms leveled at CBI are the stifling effect it has on creativity in courseware design and the low level learning (recall and simple concept acquisition) it promotes (Hannafin & Rieber, 1989a).

### 3.2.2 The Influence of Cognitive Science and Information Processing

Cognitive psychologists support a student-centred approach to learning via Information Processing theories. Prior knowledge is a primary influence in mediating learning. Unlike the behavioural approach, the learner plays a role in mediating instructional effectiveness, not the instructional materials (Hannafin & Rieber, 1989a). Sensory stimuli are selectively perceived by the learner and stored temporarily in short-term memory (STM) or working memory. This functions as a transitional buffer which regulates information exchange among ongoing instruction, prior knowledge and long-term memory (LTM) or permanent memory. Learning is said to occur with information encoding and transfer from STM to LTM.

Knowledge is mentally represented as *propositions* (declarative knowledge about something), *productions* (procedural knowledge of how to do something — a conditionally based action sequence), *images* and *schemata* (organised networks of prior knowledge). Knowledge retrieval from LTM is dependent on the quality of encoding and retrieval processes. *Organisation*, the intentional shaping of information into meaningful parts, and *elaboration*, the enhancement, extension or modification of information in the light of LTM contents, influence the encoding and storage process. *Spread of activation* evokes linkages among propositions in LTM upon retrieval, and is possibly improved with spatial mapping of text.

Information is meaningful when it can be linked with existing ideas, so instruction or performance support should progress from simple to complex and known to unknown. Cognitive software design models prescribe activities to promote learning by stimulating cognitive processing related to instructional/performance content. A range of instructional models have undergone refinement and incorporation into larger models (Reigeluth & Curtis, 1987).

The models of Bruner, Ausubel, Gagné and Merrill have all been incorporated in *Reigeluth-Merrill elaboration theory*. The two main features of this theory are that earlier ideas *epitomise* ideas that follow and the sequence is based on a *single* content orientation. An epitome presents a few of the most fundamental and representative ideas at a concrete level, then adds complexity to one part of the overview in layers (elaborations). Elaborations will differ depending on the main instruction focus — whether on what (concepts), how (procedures), or why (principles). The nature of the simple to complex will differ for each of these. The pattern is the epitome, elaboration, summary and synthesis.

All these models have been refining the tenets of cognitive psychologists about the way we learn, and the need to capitalise on **R**etrieving information from LTM, **O**rienting to the new material, **P**resentation of information, **E**ncoding of information and **S**equencing of information for optimal learning in an appropriate context — the basis for the **ROPES+** model (Hannafin & Rieber, 1989b). These are the same foundations beneath Intelligent Tutoring Systems.

The developmental view of learning in keeping with Piaget seeks similarities in student performance among age groups and postulates a developmental constraint on reasoning in terms of its concrete or formal features. Development meant progress from concrete to formal thought. Research demonstrating the domain specific nature of science reasoning has motivated a reformulation of the Piagetian perspective. The Neo-Piagetian Theory emphasises how working memory capacity influences student behaviour. It suggests that abstract reasoning can vary as a function of working memory demand rather than development. If a given problem overloads working memory, you can't think abstractly (Eylon & Linn, 1988). When the knowledge domain can be represented on the computer screen (a concrete representation), the student is then free to manipulate the knowledge directly and perceive abstract relationships.

In the March issue of Educational Technology, 1990, Merrill, Li and Jones present the second generation instructional design theory (ID2), aimed at improving interaction, increasing self-directed learning and enabling the development of Just-in-Time (J-I-T) instruction or embedded training (Merrill, Li, & Jones, 1990). Opposition to this theory follows and a special issue of Educational Technology in May, 1991, presents the first of several fiery debates. The opponents are the "constructivists".

### *3.2.3 The Constructivist-ID2 Controversy*

At the peak of the 1991 controversy, which still simmers, this quote typifies the frustration and emotion of the issue:

> *"Is it any wonder that constructivism is so much in vogue in academe? It can mean whatever the speaker wishes it to mean — a very nice example of subjectivism! " (Molenda, 1991).*

David Merrill, in his article entitled "Constructivism and Instructional Design" (1991), strongly defends ID2, supports and praises the moderate constructivist views and expresses the feeling that ID2 could do well to support these task relevant, action and experiential learning environments. He does not support the views of extreme constructivists. Perkins (1991a) characterises five facets of the learning environment, expressing the view that constructivist environments and ID2 could both support an increase in *construction kits* and *phenomenaria.* His fence sitting is a source of annoyance for some (Molenda, 1991). Constructivists are identified as WIG (without information given) or BIG (beyond information given) in their approach. The former are characterised by their total lack of use of any direct instruction and reliance on the learner "rediscovering" everything for themself.

According to Winn (1991) emphasis on instruction and performance has served well for teaching basic knowledge and skills but in the mastery of advanced knowledge in ill-structured domains, a different conception of instructional strategy seems necessary. Constructivists de-emphasise instruction and performance and place far more responsibility for deciding what and how to learn on the learner. The instructor or instructional system is there to support the learner's decision. The software used to promote learning as opposed to instruction is described as "empty" — it comprises "shells" that accept any content from users which will allow them to explore and construct meaning for themselves. The software functions as a tool which learners use to develop cognitive skills.

Hypertext knowledge bases are typically structured to reflect the organisation of knowledge or the content domain, whereas instructional systems are designed to reflect a task (learning outcome) functionality (Jonassen, 1991a). Hypertext can function as a model of schema theory. By modelling an expert's knowledge structure in the hypertext document, a useful knowledge structure may be mapped more directly onto the learner's cognitive structure. Jonassen offers hypertext systems as an alternative to ID2. He discusses the Instructional Design Environment (IDE), an interactive hypermedia system that designers can use to create courses by structuring the content and creating instructional sequences.

To the learner, the constructivist learning experience may not look welcoming (Perkins, 1991b). It may seem daunting and complex to those who feel ill-prepared for such creative freedom. Often constructivist learning situations throw learners on their own management resources with little warning, and many fend poorly in the high cognitive complexity of the learning environment. Cognitive support tools and the explicit acknowledgment of the double agenda of self-management and learning can help. The scaffolding and coaching in the cognitive apprenticeship model offer another solution.

Evaluation of constructivist learning emphasises higher-order thinking (Jonassen, 1991b). It focuses on the process within an authentic task rather than the product. Context driven and dependent, this evaluation accepts the likelihood of multiple perspectives, the possibility of a range of tasks, and the need to be evaluated by a panel of goal free examiners from a range of backgrounds. David Jonassen recommends the most effective application of constructivist learning environments is to the stage of advanced knowledge acquisition, where learners already have well formed schema and knowledge integration. Advanced knowledge must be gained in order to solve complex domain- or context- dependent problems.

The impact (conscious or otherwise) of a software designer's view of learning theory on the structure and functionality of their work is at a fundamental level, and is highly significant. Squires and McDougall (1994) only place emphasis on this feature in the designer-student perspectives interaction, yet they acknowledge that it influences learner control, complexity and challenge. It is precisely these characteristics of software which directly affect the role of the classroom teacher when software is in use. To suggest the central feature of the teacher-designer perspectives interaction is curriculum content and process is to relate to the teacher outside the classroom. at the stage of lesson planning. This ignores the special talents of the classroom teacher— the ongoing metacognitive support they can tailor to the individual level. It is also somewhat contrary to the aim of their paradigm— to focus on software use rather than attributes.

The influence of learning theory on software design feeds down both arms of the triangular Perspectives Interactions model, to meet in the student-teacher interaction. The designer is the hidden co-teacher, who implicitly sets the tone of the classroom once software is in use. Learner control is frequently analysed as a characteristic of such software, as if the learner is the only person of relevance. When a teacher selects this software for classroom use, it may be more appropriate to view the same concept from the opposite perspective— that of designer control. The nature and extent of the involvement the teacher has with the student is very much a function of the control a designer is prepared to relinquish. This answers our second question—how does a designer's style impact on the classroom. This is now discussed more fully.

## 3.3 Designer Control and the Teacher/Designer Relationship

Teacher and designer cannot simultaneously influence the student minute to minute. As Squires and McDougall (1994) emphasise, the value of some software lies in its ability to stimulate associated classroom learning activities which occur away from the computer, under the guidance of the teacher or fellow students. When the designer controls the learning sequence, allowing little student freedom, teacher involvement in the learning process is diminished. This inverse relationship between designer control and teacher involvement can be illustrated graphically (see *Figure 3.2*).

At point A, designer control of the student is considerable, so there is little room for teacher involvement. The designer has assumed the role of teacher replacement. The relationship between designer and teacher is independent. The student relates to one or the other at different times. The teacher selects the software for a particular purpose. The student uses the software. Assessment of learning is frequently within the software and relates purely to the material covered.

As the designer relinquishes control, a balance is reached at point B where the teacher involvement is fundamental to the use of the software. The relationship between the designer and the teacher is collaborative. This collaboration may occur through teacher involvement in the design process, but the crucial aspect of this style of educational software is the need for active teacher involvement while software is in use. The metacognitive support of the teacher is vital.

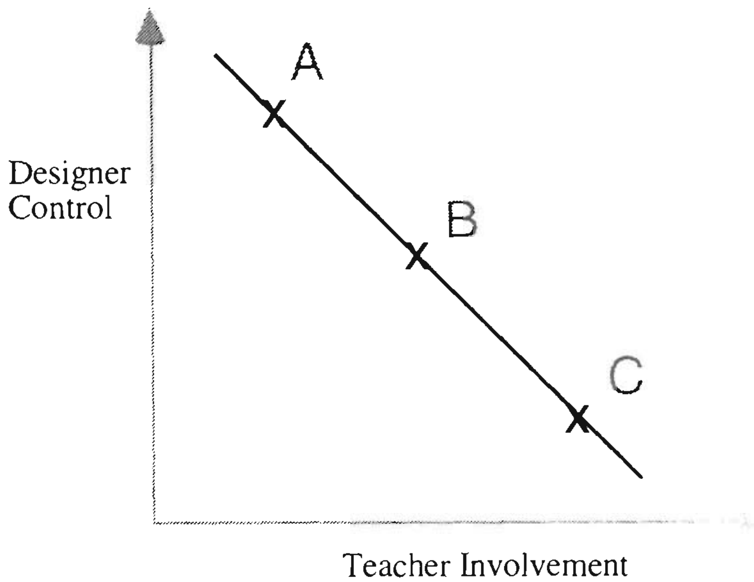


*Figure 3.2: Relationship Between Designer Control and Teacher Involvement*

The move to point C is the exciting one— where the designer has handed control over to the student and teacher. The relationship between the designer and teacher is interdependent. The teacher and designer can be one. Software in this style would characteristically be known as a "cognitive tool". The teacher may design the activity for which the cognitive tool is required, or design the cognitive tool.

In the previous chapter, the classroom environment was analysed as a series of highly variable key factors, presented in *Figure 2.1.* The complexity of this environment was enormous, given the possible combination of factors. At point A in *figure 3.2*, the designer is attempting to create a parallel environment. If the designer's task is discussed using the same model, the limitations of this type of software soon become apparent, as does the reason for the push towards positions B and C of *figure 3.2*.

### 3.3.1 Independence — Designer Assumes the Role of Teacher

When the designer assumes the role of teacher *in absentia*, they are dealing with similar factors to the classroom teacher, especially when software is written for use by a large number of students in the one course (see *Figure 3.3*).

What the designer lacks is the flexibility of resource management in the live classroom, the chance to get to know the students as individuals, and ongoing management of the metacognitive support for each individual. Tasks must be determined without finely tuned personal knowledge of students, and metacognitive support must be anticipated. It cannot therefore be personalised beyond broad strategy, prompting and feedback styles.

Strict curriculum guidelines, availability of resources, and the need to assess specific learning outcomes in an objective manner all limit the scope of the design early in production. Some resources may be presented in print, audio or video formats as part of an integrated package. However, this assumes a degree of self-regulation on the part of the learner, or whole class synchronisation if the teacher manages this additional material.

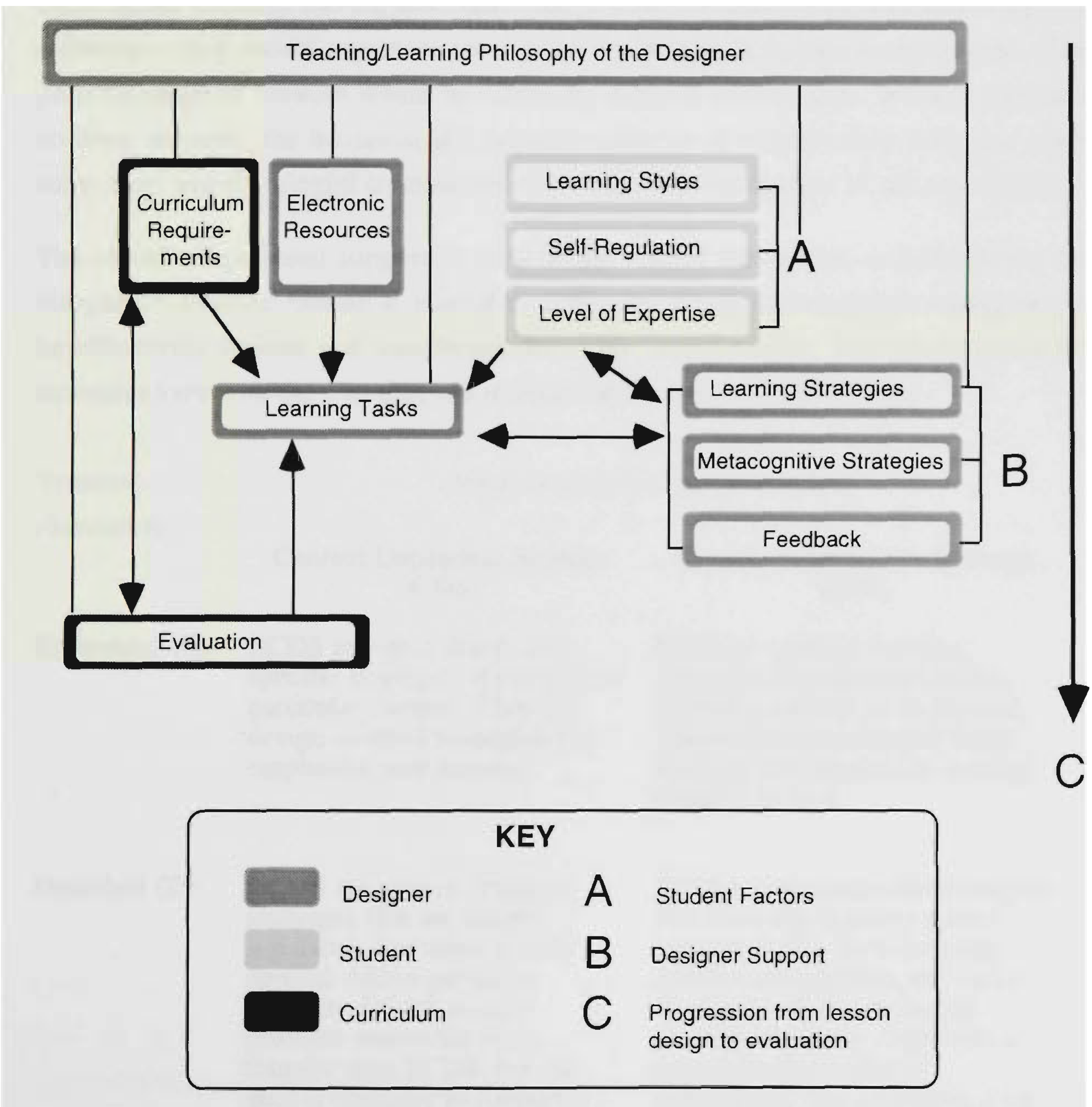


*Figure 3.3 : Factors affecting the Classroom Experience Using Software with the Designer in Control (Author's Model)*

Variations in learner expertise are generally catered for by linear progression through pre-requisite modules. When the range of interpretations of learning styles are considered, the self-contained designer will frustrate the learner who desires creative freedom, who works intuitively, who likes to reflect on work covered, who adopts a holistic approach, who processes deeply, who is interested in people more than ideas, who likes collaborative work, who is learning rather than grade oriented and who does not like the dominant media mode of delivery. There is no room for the self-regulated learner.

Open ended problem-solving and collaborative tasks are uncommon within this style of software— they would require support or feedback from a teacher or co-learners. The possible range of answers would be extremely difficult to anticipate. Without feedback on these answers, the learner is left none the wiser as to whether they have just made some deep and meaningful connections or enlarged their collection of misconceptions.

The cluster of personal support so vital to the role of the teacher is difficult for the designer to emulate. Osman & Hannafin (1992) report that metacognitive strategies can be effectively trained and transferred, but with varied results. The functions of the strategies vary with the way they are included in training (see *Table 3.1*).

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*Table 3.1: Classification Matrix for Metacognitive Strategies in Training (Osman and Hannafin, 1992, p91)*

Strategies may be embedded within a lesson, or detached and taught separately. They can be content-dependent, aimed at teaching specific lesson content, or content-independent, where they are applied across tasks or lessons. This work has been conducted purely within the context of training and instruction, which is quite an appropriate description of the use of much software designed to replace a teacher.

Metacognitive strategy training research has influenced instructional designers to:

- balance strategies with the cognitive task
- provide explicit instructions for younger learners and novices
- balance complementary strategies
- encourage learners to discuss the learning process.

Feedback in instructional design is the instructional system's response to the learner's actions. Smith and Ragan (1993) focus on the relationship between the learning task and learning outcomes. *Instructional* feedback is central to the learning process, and may include a motivational element to encourage perseverance with a task. Instructionally embedded feedback following practice will differ considerably depending on the instructional strategy, and is also distinct from feedback during assessment. Theoretically, feedback will differ for learning of declarative knowledge, concepts, rules, relational rules, procedural rules, problem-solving, cognitive strategies, psychomotor skills and attitudes. All except declarative knowledge require application of knowledge to unencountered situations. If open-ended questions are asked or reasoning is required, feedback to constructed answers will generally be a model answer or criteria for learners to evaluate their own response.

> *"Indeed, it appears that questions regarding the optimal content of feedback (as with most other instructional design questions) really revolve around the issue of the match between the cognitive demands of the learning task; the cognitive skills, prior knowledge, and motivations of the learners; and constraints, such as time, within the learning environment." (Smith and Ragan, 1993, p100).*

Unless the software is well received on its first release, it is unlikely any extra money will be spent acknowledging user feedback and channeling that into design improvements for an upgrade release. For many 'educational' packages, there is intentionally only one cycle through the design process— this highlights their role as "media" in "educational communications" (Jonassen and Reeves, 1996). Information is encoded by a team of educational technologists using a systematic design model to transmit knowledge to students.

### *3.3.2 Collaboration — Designer Works Alongside Teacher*

When the designer and the teacher collaborate, many of the designer difficulties of realtime involvement with students can be picked up by the teacher, whose expertise encompasses this area (see *Figure 3.4*).

The teacher can complement the software with additional resource material, such as guest speakers, excursions, a range of print, video and audio media, practicals and student presentations. This dramatically increases the task design options available to the teacher, and allows them to tailor use to the students they know so well. Tasks can also be modified as learner and teacher interact.

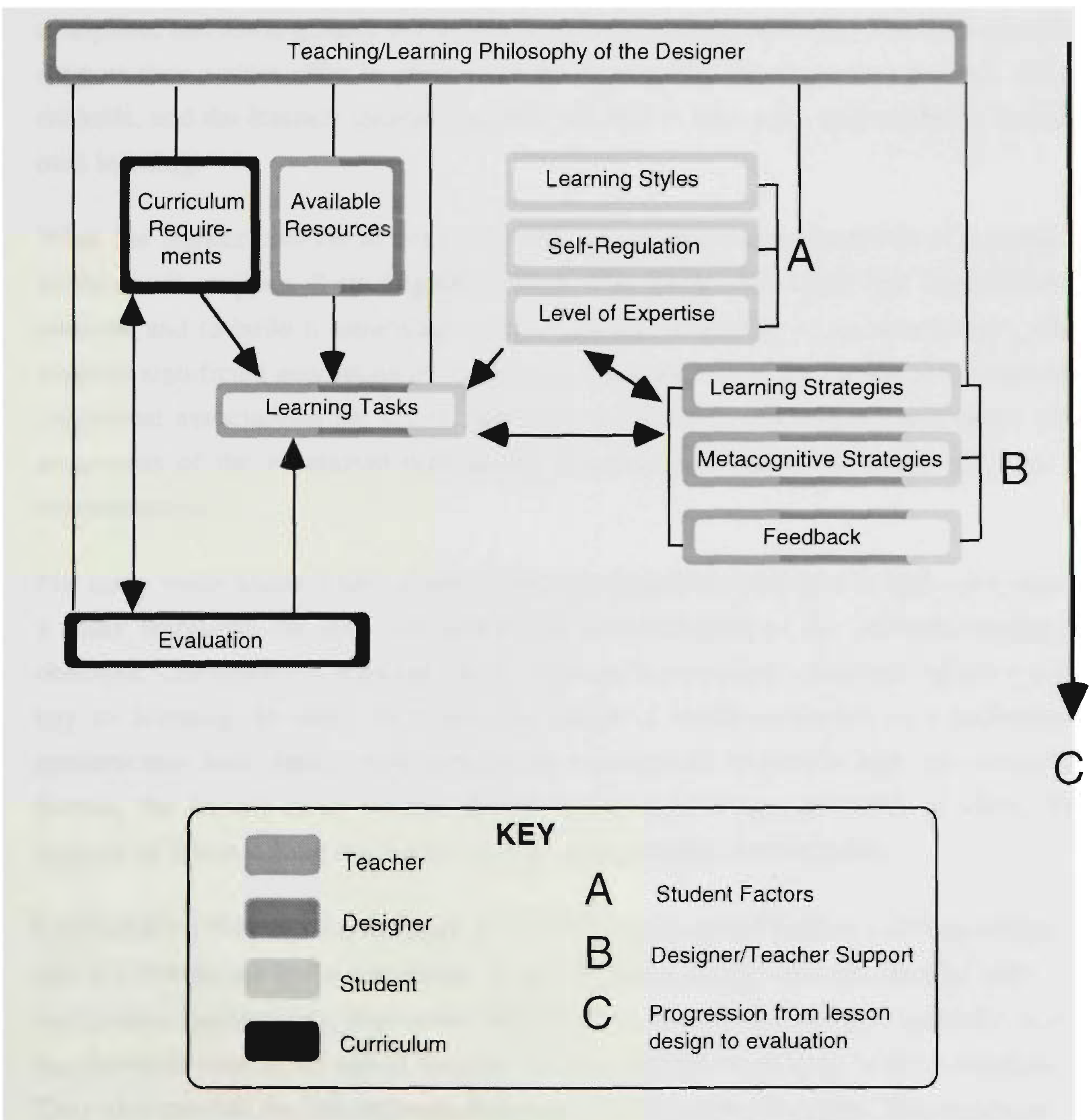



*Figure 3.4 : Factors affecting the Classroom Experience Using Software with the Designer and Teacher in Collaboration (Author's Model)*

When software is designed within a constructivist framework, it is usually structured as a non-linear hypermedia information landscape, which models and provides the learner with *some* problem-solving tasks and associated tools. Notable in the comparison between *Figures 3.3* and *3.4* is the infusion of the learner factor in task and support functions. This can occur when additional powerful, in-built construction tools are provided to allow the learner to generate and self-regulate their own tasks. Information acquired from a hypermedia environment must be integrated into the learner's knowledge structure. To relate to this new information, the learner must be able to collect, reorganise and apply it to the solution of a personally meaningful task.

The constructivist designer provides a resource environment rich in visual context, some related problem solving task options with task specific tools, as befits the discipline, and some generic construction tools to facilitate learning. The metacognitive support they cannot offer in person can be supplied by the classroom teacher, fellow students, and the learners themselves, who are free to take more responsibility for their own learning.

What the learner collects in the construction tool on various traversals of a resource landscape is stripped of its original context. The learner must take that deconstructed material and re-build it according to their own understanding of an issue or task. That requires significant annotation of material as it is collected, if the learner is to retain any contextual associations for future reference. Media rich resource environments raise awareness of the magnified complexity as you add a range of media as forms of representation.

For many years learners have deconstructed and reconstructed text in their own way as a study technique for deep and individual understanding of the interrelationship of concepts. Constructivist learning theory supports the notion that this individuality is the key to learning. In order to utilise the range of media collected in a multimedia construction tool, rather than attempt to translate all understanding into text-only format, the learner must become fluent in multimedia representation of ideas. The concept of literacy, long the domain of text, now extends to multimedia .

Collaboration between the designer and the teacher is critical both in software design, and in software use in the classroom. Teachers on the design team are familiar with curriculum requirements, successful learning strategies for their subject specialty, and the characteristics of the age of learners which enable them to "gear to the generation". They also provide the link between design and initial implementation. Teachers who are not involved in the design process need to be informed prior to software use in the classroom of the learning philosophy of the package, so they appreciate the extent of their required involvement. Software support material should include some examples of strategies for use with groups of various sizes in a range of time frames, and a description of the functionality and specific value of generic construction tools.

The key factor which distinguishes this collaborative relationship between teacher and designer from teacher involvement in the design team of stand alone *instructional* programs is the underlying constructivist philosophy. This acknowledges the importance and individuality of the learner who constructs their own understanding, and places the teacher in a co-learner facilitatory role. Design is geared to embrace maximum flexibility with minimum confusion. Information landscapes provide educational resource material in a context, along with tools to use that material in the solution of challenges within the package, or learner-identified problems.

The design cycle of this style of software is limited by financial and technical constraints of rapidly changing delivery vehicles. In theory, resource material, tools and classroom learning strategies could undergo continued refinement.

### 3.3.3 Interdependence — Designer and Teacher are Synonymous

When the designer and the teacher are interdependent, teacher involvement in the learning process within the information technology classroom is maximised. Low designer control does not equate with insignificant involvement or simplicity of task. On the contrary, the designer's job is challenging, as it is the cognitive tools they are designing (see *Figure 3.5*).

A teacher who has experienced the design process, and who is broadly skilled in multimedia production, construction and programming, is able to assume the designer role and design software for classroom use. This "disposable software", with its short development time, tends to be modular and task oriented, and can be tailored to class or even individual needs. Feedback from learners allows the teacher/designer to improve and adapt the design in a cyclical fashion. The design cycle thus passes by learners as many times as learners find the software useful. Potentially, over time, a teacher can distill and combine the best learning strategies in various ways according to student feedback. This raises awareness of what are more generic learning strategies and what are more discipline and strictly situation specific.

Alternately, a teacher who does not possess a range of multimedia production and construction skills may design tasks which involve the use of available cognitive tools, which have been defined by Jonassen and Reeves (1996):

*"Cognitive tools refer to technologies, tangible or intangible, that enhance the cognitive powers of human beings during thinking, problem-solving, and learning.*

*... Examples of cognitive tools include databases, spreadsheets, semantic networks, expert systems, multimedia/hypermedia construction software, computer-based conferencing, collaborative knowledge construction environments, computer programming languages and microworlds." (Jonassen and Reeves, 1996, pp 693-694)*

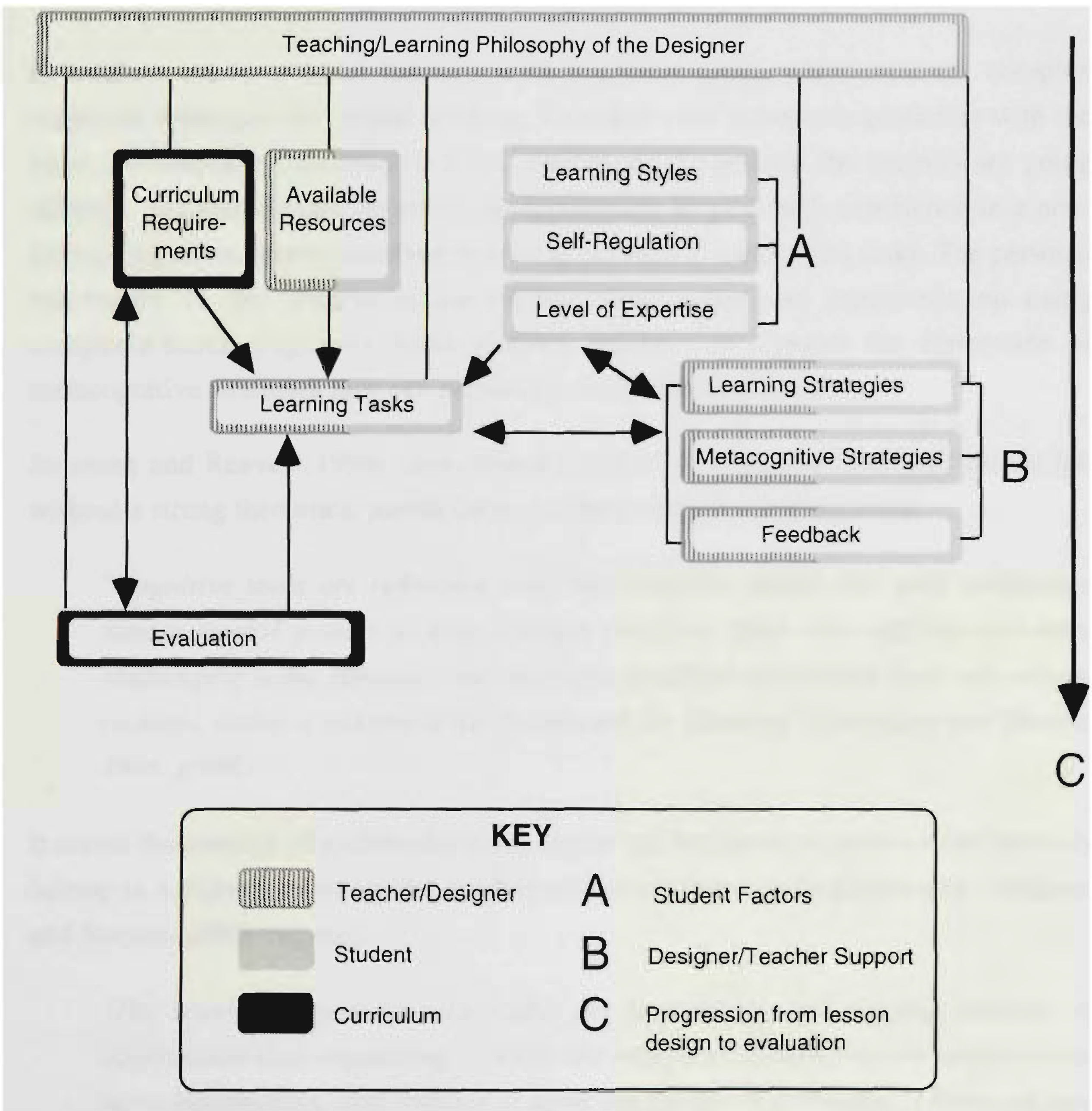



*Figure 3.5: Factors affecting the Classroom Experience Using Software with Interdependent Designer and Teacher (Author's Model)*

The *learners* function as designers, using the cognitive tools for information access. analysis, organisation and representation. The focus should not be on learning *about* the tool, but learning *with* the tool, however:

> *"Instead of using cognitive tools to solve challenging problems, pursue personal learning goals, or collaborate in accomplishing realistic tasks, computer tools have often been regarded as objects for study themselves and subjected to the same deadly instructivist pedagogy that has stymied intellectual growth by most students in more traditional areas such as science, mathematics, and social studies." (Jonassen and Reeves, 1996, p695)*

If teachers are to support learning with cognitive tools, which activate complex cognitive strategies and critical thinking, then they need to become proficient with the tools themselves— they need to have experienced the process the learners are going through. Teachers should be given the opportunity to gain such experience in a non-threatening environment, involved in solving personally meaningful tasks. The personal experience of the process of knowledge construction and representation using computer-based cognitive tools enables teachers to expand the repertoire of metacognitive strategies they can personally share with their students.

Jonassen and Reeves (1996) stress that the impact of cognitive tools will not be felt without a strong theoretical justification, and they support constructivism:

> *"Cognitive tools are reflection tools that amplify, extend and even reorganize human mental powers to help learners construct their own realities and solve challenging tasks. However, the enormous potential of cognitive tools can only be realized within a constructivist framework for learning" (Jonassen and Reeves, 1996, p 698)*

It seems the concept of multimedia construction and the use of cognitive tools naturally belong in a classroom where the teacher adopts a constructivist philosophy. Jonassen and Reeves (1996) suggest:

> *"The learner should be responsible for recognizing and judging patterns of information then organizing it, while the computer should perform calculations, store information, and retrieve it upon the learner's command" (Jonassen and Reeves, 1996, p699)*

The infusion of the classroom with computer based cognitive tools is bound to be a highly variable process, worthy of close examination.

## 3.4 Key Variables which alter a Constructivist IT Classroom

A constructivist information technology classroom is regarded by the researcher as a classroom:

- in which the constructivist learning philosophy is operational, not simply espoused
- from which students and teachers have access to a range of hardware and software
- within which learning strategies are openly shared and collaboration is practised
- which involves students in self-selected learning tasks which require active production and construction of interactive multimedia material for a particular target audience, whether that is the learner themself, or others.

This is of necessity a very broad definition— for it must encompass not only the range of classroom factors discussed in Chapter Two, but also information technology in all its hardware permutations and combinations, the diverse styles of educational software (from didactic training to information landscapes to cognitive tools), and highly varied technological expertise of teachers and support staff.

When variables which relate specifically to multimedia production and construction are hypothesised, some more obvious inclusions are the reason for multimedia production, student background knowledge in a subject, the stage of production in a course, the nature of the task, available facilities, and the technical and learning expertise of the teacher and support staff.

### 3.4.1 Reason for Multimedia Production

Multimedia production may be for the development of specific production skills, such as image digitising, the development of a specific product, such as an information kiosk about the school, or it may be to facilitate the learning process through active construction. These represent entirely different activities which place emphasis for the learner on skills, product and process, respectively. It is not sufficient to say students are involved in multimedia production and are therefore learning. The important question to ask is *what* are they learning, and what will the residual effects of this be.

### 3.4.2 Background knowledge in a subject

Content expertise is acknowledged when a learner demonstrates higher order thinking in the use of considerable content knowledge to solve real-world problems. Awareness of deep structures within the content, and multiple ways of viewing, accessing and using that content are characteristic of content expertise.

When a multimedia production exercise focuses on use of familiar content, the cognitive load of the content is reduced, thus permitting the learner to pay more attention to production processes and interface details. If production processes are the area of expertise, then the cognitive load of production should be diminished adequately to allow the learner to uncover structures within new content during the construction process. It is anticipated that serious cognitive overload would occur with a combination of novice production skills and unfamiliar content.

### 3.4.3 Stage of Production within a course

Skill development takes time to refine and automate. If students gain production skills, learning strategies and communication skills early on in a course, whether that course is at Primary, Secondary or Tertiary level, then those skills and strategies can be applied more broadly and productively to the general process of learning and communication in subsequent education. The self-regulated learner can emerge, geared to lifelong learning.

When there is no opportunity to consolidate new skills and strategies, it is anticipated that the value of the production experience will be considerably diminished.

### 3.4.4 Nature of Task - Outcome Driven or Open

Considering the range of learner characteristics embraced by the term "learning style", there will be some learners who prefer to be given a linear directed task, with full details of evaluation criteria, so they can make strategic decisions and process only as deeply as the task requires. Others may naturally desire creative freedom to develop their own ideas to considerable depth, reflect and self-monitor, then determine their own evaluation criteria.

It is anticipated that at either task extreme, there will always be some students who do not feel comfortable with the situation. Such task-related emotions do not necessarily equate with the amount or nature of material learned, the strategies developed, or the depth of understanding attained in a problem solving process. It is not easy to move out of a comfort zone, and new technology poses its own concerns for many learners. However, if there is a degree of confidence and rapport with the teacher, and reflection and collaboration feature highly in group discussion, then learners are more likely to venture into their personal unknown and invest more effort.

For skill development, specific directed tasks are an efficient means of learning. For understanding of complex content to the point of problem solving, a more self-directed task would be considerably more challenging, but ultimately more rewarding. In a constructivist classroom, the challenge is to engage the learner in a self-monitoring and self-regulating process across a range of tasks.

### 3.4.5 Available Facilities

Hardware and software available for classroom use are extremely varied, due to a range of financial, social and political forces. Hardware availability does not equate with use. Schools may have computers which sit unused for many hours due to lack of staff technical expertise, lack of funds for appropriate memory upgrades for new software, a poor selection of educational software or poor management strategies for student use. With the explosion of Internet use among the general public, students will have greater expectations of access to current facilities.

It is anticipated there are threshold levels of hardware, software, technical expertise and management strategies required to successfully access the potential of this multimedia technology for learning. For example, there may be a certain student:machine ratio required for a particular task, or a level of technical reliability below which it is just not worth using the machines. The ability to organise permanent areas of specific functionality may be important, and above all, the speed and storage capacity of networks may be crucial to avoid the frustration of excessive wait times and overload.

### 3.4.6 Expertise of teacher and support staff

A number of the above factors suggest the hardware, software and constructivist philosophy are not enough to capitalise on the unique benefits of interactive multimedia construction for learning. Even a keen teacher who wishes their students to actively use the computers may not know how to begin.

Two key areas of expertise may be needed—firstly the technical knowledge and skills of support staff, and secondly, the specialised interpersonal skills and learning strategies of the teacher, who creates an appropriate learning environment for their students, way beyond the visible realms of the equipment. Technical support staff can install systems, tend to problems, order and test software, develop protocols for student use and help manage data storage and information access. Teachers can work with support staff, while directing their focus more on learning strategies, data management, task selection and student support.

The constructivist IT classroom certainly offers no single, simple solution to learning, but it does provide very powerful tools in a rich environment for the learner. The classes which follow present in considerable detail two quite different constructivist IT classrooms— one in the computer laboratory of Koonawarra Primary School, and the other in the interactive multimedia laboratory within the Faculty of Education at the University of Wollongong. They permit reflection, strategy sharing and exchange of perspectives among all three players in the classroom— teacher, designer and student.

# Chapter Four - The Classroom Context

## Introduction

The complex role of the teacher in a constructivist classroom has been explored theoretically in Chapter Two. Technological advances which have enabled the design of software for teaching and learning have introduced a hidden co-teacher into the classroom—the educational software designer. The influence of learning theory on software design and the relationship this promotes between the designer and the classroom teacher has been highlighted in Chapter Three. It is now time to place the third actor of Squires and McDougall's paradigm— the student, on the stage. Theory and practice meet in the classroom. Two classes are described - one with pre-service primary teachers as the students, and the other with primary school students. The researcher is the teacher in both classes.

## 4.1 Rationale for the Personal Account of Researcher as Teacher

At the commencement of the study, there was little if any student construction of interactive multimedia in local schools within the Wollongong district. Though the black and white version of the multimedia construction tool HyperCard® was available on all new Macintosh® computers, one of its colour-capable counterparts—HyperStudio®, used in this study, was not supplied to the local market. The limited number of multimedia-capable machines in schools placed no demand on software distributors to handle such software.

In order to study student construction of interactive multimedia, it was necessary for the researcher to adopt the role of teacher and initiate classes which could be closely monitored. These classes would need to be selected on an opportunistic basis, since computer access was a crucial factor in their selection.

The nature of class content and process was derived from the driving research interest in active student involvement with interactive multimedia. The goals of the study were interpretivist and developmental. The researcher was focused on describing and interpreting the process of student construction of interactive multimedia. At the same time, it was hoped that innovative approaches to classroom integration of information technology may emerge. The researcher had considerable classroom freedom to develop new teaching strategies. Thorough documentation of classes would enable the researcher to present the teacher's perspective alongside observations of student work.

Lancy (1993) regards the personal account of the teacher-as-researcher as a self-generated case study:

> *" What happens when teachers do their own research? Here we have, usually, case studies that are self-directed. However, as we will see, only occasionally do the teachers writing in this area reveal enough of themselves to qualify their works as personal accounts." (Lancy, 1993, p200)*

Due to the extensive research diary (*PhD Diary*) kept by the researcher throughout this study, these classes are regarded as components of the researcher's personal account, rather than case studies. Lancy (1993, pp 142-143) lists seven general attributes of the method "case study". Of these, the following five do *not* apply to at least one of the classes conducted by the researcher:

- the audience may include the academic community, but it must include some well-defined "client" group. Often this group is one in authority.
- "professional responsibility" may be met with an oral report rather than a published document
- case studies are often undertaken "under contract", hence the researcher's motives are pecuniary, rather than a quest for knowledge for its own sake
- although a case study is not always construed as an evaluation, the researcher will assume an evaluative stance
- the researcher is obligated to draw some pointed conclusions from the case study, explicitly or implicitly making recommendations that will alter policy/practice

Therefore, the term "case study" has not been applied to the classes conducted in this study. Superficially, the action research framework would also seem to fit classes where the teacher is researcher. However, the emphasis in the classes was not on the evaluation of a program, method or product. Given the enormous breadth of the term "interactive multimedia", and the many past studies which incorporate the term in their titles, the scope and purpose of these classes require further definition. The first filter which has been applied to the term interactive multimedia deals with scope, and places the emphasis on education, versus entertainment. Within this plentiful domain, the second filter deals with purpose. It is rather more fine grained, and eliminates many of the areas of popular study. This filter addresses *learning*, rather than teaching. It dismisses the use of interactive multimedia as a *teaching* tool, to be compared with other forms of *course delivery*. For two courses to be comparable, they should be designed to guide students to the same outcomes. To constrain the potential of multimedia tools to what can be achieved by alternate means seems counterproductive.

The focus is placed on multimedia as a learning tool, and the impact this has on the nature of the learning process and process outcomes.

Close observation and monitoring of students and teacher/s is required in classes where multimedia construction occurs. The observation of more than one class enables the identification of any common factors. Interactive technologies must be available as presentation, thinking and production tools for both the teacher and learners.

## 4.2 Researcher as Teacher and Designer

Aust and Padmanabhan (1994) review 847 articles in the professional journals of the Association for Educational Communications and Technology (AECT) from 1953 to 1993, to ascertain the trends and develop insights for directing research and development agendas that involve teachers in design and use of educational technology. They are interested in reasons for failure of a culture to accept change, such as the threat to security, lack of understanding, no perceived need for change, and directing of innovation by outsiders.

Four categories are listed to consider when introducing technological change into a culture. The percentage of the 847 articles which refer to each of these categories is revealed in *Table 4.1*.

| *Key Factors in Acceptance of Technological Innovations* | *Percentage of Articles Mentioning the Factor (1953-1993)* |
|---|---|
| Recognise the group's unique identity | 26 |
| Assist the group in understanding and using the technology | 14 |
| Empathise with the group environmental and cultural needs | 13 |
| Empower the group to meet those needs | 10 |

*Table 4.1: Percentage of Articles Acknowledging Key Factors in Acceptance of Technological Change - AECT 1953-1993 (Aust and Padmanabhan, 1994)*

Empowerment through technological innovation is expressed the following way:

*"when a group of people addresses needs or receives benefits that cannot be met by current strategies or technology" (Aust and Padmanabhan, 1994, p18)*

A teacher who is fully aware of the public expectation of their role, of the responsibility they have to the students in their care, and of the rapidity with which technology is changing their culture, is willing to accept that change if they are acknowledged and involved in the process. Constructivism is accepted in the classroom as a means of assisting deeper learning and fostering self-regulation, through respect for the value of the individual's thoughts and ideas. The constructivist teacher is not always given the same respect and responsibility by education and political systems which would seek to impose change without consultation and inclusion. Peter Senge develops the concept of the learning organisation, and refers to the need for systems thinking:

*"... a conceptual framework, a body of knowledge and tools that has been developed over the past fifty years, to make the full patterns clearer, and to help us see how to change them effectively." (Senge, 1992, p7)*

Systems thinking is a cornerstone which also requires personal mastery, acknowledgment of mental models, building shared vision and team learning. Teachers must be able to share a vision of where they see the education system heading:

*"When there is a genuine shared vision (as opposed to the all-too-familiar "vision statement"), people excel and learn, not because they are told to, but because they want to.*

*... All too often, a company's shared vision has revolved around the charisma of a leader, or around a crisis that galvanized everyone temporarily." (Senge, 1992, p9)*

While the current state of education systems is described as near crisis point, short term solutions will be imposed, and these cures can often be worse than the disease:

*"Sometimes the easy or familiar solution is not only ineffective; sometimes it is addictive and dangerous. ...The long-term, most insidious consequence of applying non-systemic solutions is increased need for more and more of the solution. This is why ill-conceived government interventions are not just ineffective, they are "addictive" in the sense of fostering increased dependency and lessened abilities of local people to solve their own problems." (Senge, 1992, p61)*

The statistics of Aust and Padmanabhan (1994) indicate that teachers, despite their expertise, receive little recognition in the literature on the development of education technology, and there is even less awareness of their classroom culture and few attempts to address their specific needs. They are often by-passed by instructional designers who focus on *teaching* tools, and the computer-user interaction. The designers of Type A software (*figure 3.2*) make the assumption when they design their product that there will be minimal input from a classroom teacher. Senge (1992) notes the vision which guides any change must be shared, and warns of the dangers of the imposed "quick fix".

An observer within a classroom/computer laboratory is not aware of the teacher's preparation time, or the follow-up, or the reasoning behind certain teaching strategies or classroom organisation. Their presence alone alters the nature of the class. By assuming the role of the class teacher in each of the classes, the full weight of organisation and responsibility could be felt by the researcher. This dual role of teacher/researcher is one which should be encouraged, in order for the benefits and disadvantages of the use of new technologies to filter through to other teachers and researchers in an appropriate language.

Due to the concurrent instructional design, workshop and production experience of the researcher, and the focus of this study on learner construction of their own knowledge representation, there is a crucial third role adopted by the teacher/researcher — that of designer. These classes explore the multi-faceted teacher/researcher /designer role. The designer hat is worn between classes, when creating performance support tools or constructing the next activity, and within classes any time multimedia production and construction issues arise. This differs greatly with the nature of the class and the stage in the course.

Of interest is whether the addition of the designer to the dual teacher/researcher role is a conflicting distraction, or a complementary and necessary viewpoint. It is anticipated that with continued exposure to the interactive multimedia production process within classes, and the subsequent alteration in the relationship with students, that a teacher will naturally develop more of the skills and adopt more of the perspective of a designer, aware of the recursive nature of design. Ultimately, the designer role should influence then blend with teacher, researcher, and the myriad of administrative, personal and social roles normally assumed by a teacher during the course of a working day.

## 4.3 Basis of Course Content and Structure

The idea of learning by construction receives theoretical support in constructivist literature. This study emphasises multimedia construction. What are you constructing? Your own representation of knowledge. In the past, the linear format of text, image, video or sound presentation has been the standard format, and writing or graphic or video or musical production skills have been highly valued. Tertiary academic appraisal relies on logical development of argument in a thesis as the ultimate demonstration of knowledge expertise. Interactive technologies now provide a wealth of new thinking and construction tools. It is possible to represent knowledge using a range of media, and to organise these media in a way which suits yourself. What are the restrictions here? Your level of skill using the tools, your ability to compose or edit media resources, and your creative imagination in the orchestration of media within the structure of a media landscape.

Never before has the complete intellect been engaged in this way to facilitate harmony between intuition and logic, and thus nurture creativity. The much touted benefit of multimedia— support for different media preferences (Smith and Westhoff, 1992), has a deeper meaning than selecting a preferred media mode within an instructional program. When consideration is given to the individual in output or *production* mode, they are free to express developing ideas in whatever medium they are capable of at a particular point in their evolving understanding. Many people can draw an image before they can explain a concept, or write about it fluently, so the ability to express ideas in either hemispheric preference— text (written or spoken) or image (still or movie)— allows the learner to demonstrate understanding at the level of their current ability or in the appropriate media mode.

In an attempt to redress the imbalance of left hemispheric dominance in our schools, the *metaphor* is advocated by Sanders and Sanders (1984) as an excellent model for engaging right hemispheric preferences of imagery and holistic, conceptual understanding:

> *"With the metaphor, the sequential, factual, verbal knowledge of the left brain becomes "real" to the right brain, which assumes a pattern, an image of what the "big picture" means. As such, the metaphor provides a bridge between the two separate thought processes of the brain, a bridge that allows imagery to be verbalised and creates imagery for specific facts." (Sanders and Sanders, 1984, p19)*

Creativity is a highly desirable quality in students, and represents both conscious thinking of the left brain and spontaneous patterning and imaging of the right brain:

> *"Creativity is the product of their merger, the product of loosening the bonds of order and predictability, the result of valuing the unusual connections and alternative images the right brain offers, while utilizing the left brain's ability to order and sequence these connections and images into a logical perspective." (Sanders and Sanders, 1984, p25)*

It requires an attitude which permits curiosity, images, unpredictability and chance combinations to be possible guides in learning— it fosters an irreverence towards established norms. The spontaneous nature of "right brain thinking", capable of simultaneous appreciation of countless options, and thriving upon the experiential process rather than finished product, needs nurturing. Creative thinking:

> *"requires a climate where spontaneity, simultaneous alternatives, and process itself are valued and fostered, where products are not the "raison d'étre" for the experience." (Sanders and Sanders, 1984, p33)*

Creative teaching, which involves novel strategies or techniques, is *not* the same as teaching for creativity, which is aimed at enhancing creative behaviour in the learners.

Beichner (1994) exhibits creative teaching in a case study of 9 "reliable and available" year 7-8 students who worked several hours per week on a project which spanned one year. They were accompanied at various times by 11 adults— 2 computer coordinators, three teachers and 6 zoo and museum staff. The latter hint at the specialist nature of this project— the venue was a technology-rich school within grounds of a large metropolitan zoo. The task was to create touch-screen presentations for the zoo, using high-technology hypermedia editing software with inbuilt video and audio editors. Initially the teachers told the students how to use equipment, what to process and where to put it. This changed over a number of weeks, as students expressed a strong desire to work on their own. Students were concerned with information accuracy, acutely aware of their target audience, and moved from concern with the technology to focus on content and structure. The students saw themselves as "programmers".

In the theoretical foundations of the study, Beichner highlights a distinction between constructivism and *constructionism*::

> *"We understand "constructionism" as including, but going beyond what Piaget would call "constructivism". The word with the v expresses the theory ...The word with the n expresses the further idea that this happens especially felicitously*

*when the learner is engaged in the construction of something external or at least shareable... This leads us to a model using a cycle of internalization of what is outside, then externalization of what is inside and so on." (Papert cited by Beichner, 1994, p57)*

Emphasis was placed on the benefit of realistic tasks, and the editing process for media selection. The students in this study were externally motivated by interaction with their target audience—zoo visitors, who were appraising screens. Over time the students developed an awareness of the need for navigation, and sophisticated media editing strategies which ensured that content was learnt. The key finding from the study:

*"... is not that technology improved learning or that the unique zoo setting made the project successful. What became quite clear while examining the data is that students saw that the work they were doing had importance outside the classroom. It was worthwhile for them to learn new material and uncover additional resources. " (Beichner, 1994, p67)*

Wilson (1993) acknowledges the power of developing hypermedia products to gain expertise in the associated knowledge domain. Hypertext tools allow students to create non-linear structures with conceptual organisation. The power resides in the information processing along the way:

*"In order to prepare content and organize it for a hypertext report, students must become very familiar with the content and its organization, become a "mini expert".... In-depth learning of content creates a conceptual framework for understanding how the content is organized and for applying content knowledge to novel but related information." (Wilson, 1993, p656)*

The step from browsing to authoring using a collaborative hypertext tool can be frustrating even for average level computer users, according to a study by Kacmar (1993). The most basic difficulties concern the structuring of the hypertext and the process of quantifying the amount of information to place in a node. An important finding relates to object proximity:

*"Although a hypermedia system may provide a very simple and fast mechanism for creating links, nodes may become overpopulated as users attempt to position information as close as possible. This can result in nodes which contain different ideas and/or are illogically chunked; and, hypertexts which are flat or have no obvious logical structure." (Kacmar, 1993, p277)*

Nix (1990) introduces the novel concept of dignity in association with computers. Dignity in this sense is the ability of the student to remain intrinsically different from the way a computer functions, to be free to consider process and feelings, and to be unpredictable in a creative way. Not only is criticism directed at what has been described in Chapter Three as type A software (*figure 3.2*), but also at type C software of the programming variety, where the process is predictable:

> *"The problem-solving technique is computeristic. The domain of expression is defined basically in conceptual schemes related to computers, such as algorithmic thinking, procedural thinking, logical debugging, and modularization." (Nix, 1990, p147)*

Nix raises the issue that the computer "should not know what you can do with it", and places emphasis on student self-expression. The environment in which the computer is a "decentred participant" involves aesthetics, social interaction, humour and much student personality. Computer-related activities are part of a range of other activities. A different genre of computer use is proposed, where:

> *"The computer was a means for bringing together what the students were doing, and of presenting what they were doing in a manner that could be interacted with, enjoyed, and discussed by others. The computer was a means for enabling a focus on how to express the ideas being developed with each project. (Nix, 1990, p160)*

The adoption of computers in schools is not a neutral event (Durrell, 1990), and teachers and students need to come to terms with them on their own level. In a three year assessment of the introduction of computers into a school, Durrell notes that most teachers progressed from personal concerns about the classroom computers to levels of task orientation. They confronted the machines and strove to become effective users. By the end of the third year, they were looking for ways to use the technology most effectively. The major lesson learnt from the study is that:

> *"...time is needed for people to make sense of new technology so that they can construct useful and personally meaningful models of computer use. Intensive training could speed the teachers and students toward superficially efficient computer use, but the kind of deep and personal understanding that the people studied in this project were building is unlikely to disappear when the project ends." (Durrell, 1990, p761)*

The synthesis of these superficially disparate reports tells a story of its own. It takes time for a teacher to develop fluency with computer use, to the point where they can focus on the quality of learning (Durrell, 1990). Teacher awareness of the distinction between process and product allows meaningful selection of activities. Creativity and right hemispheric preference is fostered by a process focus (Sanders and Sanders. 1984), as is the acquisition of deep conceptual structure (Wilson, 1993), provided the cognitive load of the tool is not too great (Kacmar, 1993). Product focus provides external motivation, allows knowledge of a target audience, and can assist the learning of content through the media editing and selection process (Beichner. 1994). It is possible to balance process and product if the computer is "decentred", providing one of many classroom activities in the broad process, and orchestrating the overall product to share with others (Nix, 1990).

The classes with pre-service primary teachers (EDUM courses 221 then 212) and with primary students (G&T) would require very different structures, due to the nature of their respective environments. The pre-service primary teachers would work in a multimedia laboratory at least three hours per week. The gifted and talented primary school students would work within a school computer laboratory approximately one hour per week. Classes would also seek different process outcomes. The pressures placed on the tertiary students by task deadlines and competitive evaluation would not apply to the primary students, who would be free to select the focus and nature of their work, and extend interest areas to fill available time.

There was evidence in the literature to support the concept of learning through the construction process. Of interest to the researcher was the nature of the learning process when the emphasis was placed on process freedom (G&T), versus skill development and product quality (EDUM courses).

Discussion begins with the context of the first semester course "EDUM 221: Information Technologies and Multimedia" for pre-service primary school teachers.

## 4.4 Class EDUM— Pre-Service Primary Teachers

### EDUM 221— Information Technologies and Multimedia

#### 4.4.1 Context

*People* : EDUM 221 was an elective subject in information technology for pre-service primary teachers, run by the researcher and a co-lecturer. Fourteen students from the Bachelor of Teaching in Primary Education program — eleven from second year and three from third year, participated in the course. Eight students were females, and six students were males— a surprisingly even balance given the predominance of female students in the faculty.

*Place* : Three-hour classes were held each Thursday afternoon throughout Semester 1. 1994, in the interactive multimedia laboratory within the Faculty of Education at the University of Wollongong. The co-lecturer conducted a lecture/demonstration in the laboratory in the first hour; the researcher guided students in practical work for the remaining two hours. There was some degree of flexibility in this arrangement, in response to demands of software production. Some weeks practical work occupied the full session.

*Multimedia Production and Construction:* Course components were structured:

- to enable students to develop skills using a broad range of applications and hardware in the process of digitising resources
- to enable students to develop basic skills using two multimedia construction products—HyperStudio® and HyperCard®— which varied across a range of characteristics
- to enable students to experience the design process following a series of lectures on instructional design
- to enable students to develop awareness of the relationship between program content and program structure
- to share information technology classroom strategies with students, acknowledging their dual role as learners and future teachers
- to enable students to familiarise themselves with a networked environment and resource management
- to model and assist the development of problem-solving strategies with hardware and software
- to group students singly, in pairs, in small group and whole group formats to allow them to trial and acknowledge their response to collaborative work with computers
- to enable students to peer tutor as a technique for evaluating skill development
- to assess students using mastery for skills and graded scales for individual and group tasks, to allow them to experience as a learner a range of evaluation strategies with information technology

This list of course components does not represent course aims, which encompassed both practical and theoretical strands. It relates purely to multimedia production and construction. It was anticipated that theory would influence practice.

### 4.4.2 Background

*Students* : The second year students had experienced an introductory course in information technology the previous year. They were familiar with the researcher as a lecturer and tutor in information technology. HyperCard® was used in one laboratory session in the compulsory first year course in an extremely cursory way. The three third year students had minimal exposure to computers within the last year, apart from their use as word processors for assignment work.

*Teachers* : The co-lecturer was a highly experienced and internationally acknowledged instructional designer and researcher within the field of Information Technology. The researcher was a PhD student in her second year of candidature, but third year on campus. She had two years' experience in instructional design, programming and graphics. The first of those years was also a time of immersion in literature on constructivism, metacognition and interactive multimedia. The second year was spent lecturing in Information Technology, Science education and the "Design and Make" elective.

### 4.4.3 Resources

*People* : The technical officer assisted with the testing of equipment, particularly for video recording of computer projections in the "Show and Tell" sessions.

*Machines* : For most classes there were eleven networked Apple Macintosh computers available for student production. Machines ranged across such models as the Quadra 950, Centris 660 AV, II ci, Cx, Fx, LC and Centris 650. Hard disk space was limited to 40 Mb on three machines, most had between 8 and 20 Mb of RAM, and all were linked via Ethernet to a server with a fluctuating capacity ranging to several hundred Mb. Permanent full colour projection facilities were available on the demonstration machine. From week 10, a 540Mb external hard drive was available to compile student work for demonstration sessions.

Resource production was achieved using a Sony Super VHS video camera with tripod, Marantz tape recorder , Canon Ion Camera, Sharp Colour Scanner, and VideoSpigot digitising board, which was located in the Quadra 950.

*Media* : Some scanned images and video clips from a commercial royalty free CD "Animal Kingdom" (Aris™ Entertainment) were provided for students in the early stages to assist skill development with media compilation in a tutorial session. Due to student selection of their own topics in subsequent tasks, media requirements could not be anticipated, and were no longer the domain of the teachers. Part of the production process involved students seeking out and producing their own resources. The education resource centre for the Faculty of Education was located in the same corridor as the laboratory, and thus provided a handy source of information for students.

*Teacher Tools* : Teacher tools were of print, video and software nature. The print tools included:

- class activity sheets, distributed at the beginning of each class, outlining what we anticipated covering within the 3 hour session (see Appendix A)
- detailed step-wise original tutorial documents for HyperStudio® and HyperCard®
- worksheets to accompany group discussion on resource format requirements for HyperStudio® and HyperCard® (see Appendix B)
- HyperStudio® exercises from "Hands on Multimedia for Teachers" (Abernathy et al, 1993) and "Hands on Multimedia for Kids" (Abernathy et al, 1993)

Video was used as a teacher tool in three ways:

- computer to video output of the complete HyperStudio® tutorial was produced for students to watch directly before they completed the same task. Notably there was no sound on this video, so students had to concentrate on watching the procedures.
- The live demonstration of the HyperCard® tutorial was video recorded off the projection screen for the two students who were absent from that class, so they could view the demonstration at a later time. This video had sound, and was value-added due to the inclusion of student questions and their answers.
- for "Show and Tell" sessions, where students demonstrated completed software tasks, the demonstration machine was used. As students presented their work, it was video recorded off the full-colour projection on a large screen. This avoided problems of flicker, and permitted student comments and discussion to be simultaneously recorded. The video output was linked to a TV monitor, so students themselves were able to adjust camera placement and focus.

A range of software tools , considered "disposable software", were produced in HyperCard®. Several stacks functioned to link student work for display, model a potential teacher tool in a classroom, or reflect technical details back to the class:

- *HyperStudio Tasks* - linked all student HyperStudio® stacks for easy display, coupled with group comments transcribed from the video of the "Show and Tell" session.

- *Student Evaluation* - contained a card for each student, their image, and the results of early assessment tasks. It modelled a classroom tool and also provided a discussion forum for student evaluation from the teacher perspective.
- *Technical Details* - Recorded and reflected back to the group the latest findings on technical issues, in order to avoid unnecessary repetition of errors.

A performance support tool was built to assist skill development in HyperCard®:

- *Begin With HyperCard* - provided a single card template containing a palette of facilities for adding media, a visible number or name on each card for orientation, and navigation options to facilitate early movement prior to navigation button construction.

A tool for collecting anonymous student feedback was prepared:

- *UM Thoughts Week 10* - a stationery pad for students to copy and anonymously provide feedback on feelings about resource digitising proficiency and the group project

Finally, another link tool with extra functionality was constructed, to model the way a metaphor could integrate work for the group project:

- *Background* - created for week 11, to provide a possible framework for the group project. It contained a notepad facility to collect information, and linked all student HyperCard® stacks in the "library" screen.

### 4.4.4 Anticipated Process Outcomes

It was anticipated that students would become proficient at digitising images, sound and video for their incorporation in a range of productions. HyperStudio® was used as the first construction tool due to its simple interface and powerful functionality across colour graphics and animation. HyperCard® was considerably less "user friendly" in the early stages, but ultimately more powerful and flexible with its HyperTalk® scripting language. With this progression from one commercial product to another within the same application category, it was hoped the students would be able to discern the pattern of overall functionality of such products, variations across each functional component, and thus anticipate such variations in functionality in any further similar product they may use.

The broad range of applications used for media digitising was expected to enable students to develop confidence with such applications, experiment with their wide options, and begin to select appropriate applications for different self-generated tasks and effects.

The leap from basic computer proficiency in the compulsory introductory Information Technology subject offered in first year, to the increased sophistication of skills and concepts in this course, was not considered a problem due to the high percentage of course hours involved in practical work, and the location of all classes in the multimedia laboratory. It was anticipated that task involvement and immersion in the technology would facilitate the transition from relative novice to competent producer.

Students were geared to competitive assessment procedures in many other courses—graded marks are a course requirement. The mastery assessment of skill development, worth 45% of course marks, was expected to concern some students. The incorporation of collaborative student groupings and a group mark for the major group project was also testing new ground. It was anticipated that grade oriented students may not appreciate this arrangement, and may not find the collaborative course components comforting. While they were learning about the benefits of collaborative work in other subjects, this course would challenge their own feelings through experience.

With a limited exposure to instructional design theory through a brief series of lectures and software demonstrations/evaluations, it was anticipated that while students would have heightened awareness of instructional design issues, they would not have the time or skill level to incorporate many of these principles in their productions. This would parallel the difference between browsing and authoring hypermedia.

## EDUM 212—Information Technology Development Project

### 4.4.5 Context

*People* : EDUM 212 was an elective subject in information technology for pre-service primary teachers, run by the researcher. This elective was a continuation of EDUM 221- "Information Technologies and Multimedia". Five students from EDUM 221 — all from second year, continued with this specialist elective. Two students were females, and three students were males.

*Place* : Three-hour classes were held each Thursday afternoon throughout Semester 2, 1994, in the interactive multimedia laboratory within the Faculty of Education at the University of Wollongong.

*Multimedia Production and Construction* : With the small group nature of the course, it was structured:

- to enable students to negotiate the course outline and evaluation criteria in the first week

- to enable students to experience the design process with a major individual project of their own selection over an extended period of time
- to enable students to refine skills using a broad range of applications and hardware in the process of digitising resources
- to enable students to develop animation skills, and create an educationally sound example of its use
- to foster an atmosphere of collaboration
- to enable students to extend scripting skills using HyperCard®
- to enable students to develop a new program structure appropriate for their content
- to enable students to assume the metacognitive load of their own resource management
- to model and assist the development of problem-solving strategies with scripting, resourcing, time management and instructional design
- to enable students to peer tutor when their skills were required
- to assess students on a graded scale for their major project, with both lecturer (40%) and peer (20%) contributions, to allow students to experience the role of evaluator.
- to assess students on a graded scale for their project documentation (20%)

### 4.4.6 Background

*Students* : The five students who chose to continue with this specialist information technology elective had all demonstrated considerable interest throughout EDUM 221, spending many extra hours in the multimedia laboratory. A number of other students from EDUM 221 had expressed the desire to continue, but were required for academic reasons to select another subject.

### 4.4.7 Resources

*People* : The technical officer continued to offer support. The decrease in student numbers from 14 to 5 was not reflected in the amount of time the technical officer spent with students.

From the student perspective, many people provided information and assistance, particularly in three projects which extended out into the community:

- one student worked with a class of year 1 children with year 5 helpers in a local infants school. The aim of the project was to allow teachers to build a program with student work. Hence the children provided the resource material for this template.

- one student worked in with a local Field Study Centre, designing a program to extend the benefits of school excursions.
- one student focused on Aboriginal culture, and was fortunate to witness and video a unique display of dancing by the La Perouse Dance Troop, who were visiting Koonawarra Primary School

In the remaining projects, the students focused on subjects which were either of major personal significance (world peace) or ideal cross-curricular themes of individual interest (the home of the 1960s). In these cases, the students either generated the content, or became the principal researcher.

*Machines* : Late in semester 2, 1994, a number of new computers were purchased for the interactive multimedia laboratory. Many of the older machines were replaced by Apple PowerMac 6100 AV or 7100 AV models. The changeover of machines caused a number of network software problems, and some software incompatability with non-native applications on the PowerMacs. With the addition of a PowerMac 8100, there was an alternative to the Quadra 950 for video digitising.

All additional resource production facilities remained as they were for Semester 1.

*Media* : Students resourced their own projects. Image scanning featured prominently in all projects. Video shared the limelight with images and sounds in two projects.

*Teacher Tools* : Teacher tools were of print , video and software nature. The print tools included:

- the proposed course outline, for student input and negotiation in week 1
- stack script documents to accompany live demonstrations of functionality. These allowed students to annotate the scripts and note possible use of strategies or functionality (see Appendix C)
- detailed notes on the principles of animation in AddMotion II (HyperCard®) and explanation of menu options
- butchers paper for brainstorming and group discussions— this was kept for later reference and reminder
- a negotiated project evaluation grid for completion during project presentations

Video was used as a teacher tool in two ways:

- Students talked to the video camera, expressing project ideas, and describing their current situation. This was both an alternative to a written diary entry, and a means of developing verbal expression in the specialist field of information technology. (Without the chance to use new vocabulary, confidence with oral presentation of material was less likely to develop.)
- for the animation task and major project presentations, the demonstration machine was used and the large screen projection was video recorded in the same manner as had occurred in EDUM 221.

A range of software tools were produced in HyperCard®. The key function of all the stacks was Performance Support :

- *CB HyperCard Info* - provided a colour reference stack on HyperCard®. This contained extensive information on the key structural and functional components of HyperCard®, and the key principles of the HyperTalk® scripting language, with inbuilt examples
- *MC Master, EDUM Diary, EDUM Demonstration, New Media & ShowList* and *Search Menu Read Write* were a collection of stacks tailored to demonstrate specific programming structures or functionality, ranging from template architecture to automatic card with date generation, to creation of menus, the ShowList function, search strategies, and text reading and output to disk.

### 4.4.8 Anticipated Process Outcomes

It was anticipated the students would develop significant metacognitive skills as they adopted a self-regulatory approach to their major project, which extended right throughout the semester. Resource production skills would be honed and developed as students sought unique solutions to tasks they had set for themselves, in the framework of their project. With more exposure to the networked environment, it was anticipated students would develop better mental models of where resources resided, and deal with the issue of pathnames.

The ability to select their own projects was expected to increase students' internal motivation towards the process. They were given the opportunity to select a topic of intense personal interest or something which would provide a teaching resource for future classes. Either option was to have educational validity for the target audience in the K-6 group.

The inclusion of animation techniques touched on the most complex resource. This was intended to stretch those students with programming proficiency, and provide all students with the challenge to use this "fun" technique in a manner that demonstrated "education value" to the viewer.

The chance to develop a project over a semester time frame, with intensive weekly small group discussion, was expected to develop close collaborative ties amongst the students and teacher. It was assumed discussions about instructional design principles, covered briefly in EDUM 221, would increase as students had the need to consider them.

Realistically, the three hour session each week was expected to extend into many hours in particular weeks, though the group was cautioned in the first week not to let this project consume their time to the detriment of other subjects.

## 4.5 Class G&T—Gifted and Talented Primary Students

### 4.5.1 Context

*People* : Twenty two gifted and talented students (ten females and twelve males) from nine local primary schools met one day per week—Thursday, for an extension class, under the guidance of a teacher who worked exclusively with this class. One hour each Thursday was timetabled for computer work. The researcher was responsible for developing and supporting the activities which occupied this hour. A voluntary assistant— a student from EDUM 221 then 212, accompanied the researcher for 21 of the 27 classes. The class teacher was present for the computer hour, so the standard teaching team during the computer hour for twenty one weeks was the trio of researcher, class teacher, and student assistant . A parent of a student in the gifted and talented class the previous year offered his time, equipment and considerable video production expertise on eight occasions.

*Place* : The gifted and talented class was conducted in the computer laboratory at Koonawarra Primary School. Computer-related activities led students at different times to the regular classroom, the props room, the library and the school grounds.

*Multimedia Production and Construction* : The "flexible" computer hour (additional time was subject to availability) was structured:

- to enable students to express themselves using voice, acting and written expression
- to enable students to produce a range of their own resources— video, sound, images and text—for computer coordination
- to enable students to work with computers singly, in pairs, and in small groups

- to enable students to develop basic skills using HyperStudio® as a multimedia construction tool
- to model and assist the development of problem-solving strategies with hardware and software
- to allow students to select a project according to their interest, and work with a group sharing that interest
- to enable students to share their skills through peer tutoring
- to reflect student ideas back at the group through demonstrations of student work
- to support collaboration and discussion of strategies
- to support the creative process, rather than emphasise product quality

### 4.5.2 Background

*Students* : Students had been nominated for the class by their classroom teachers. No information was sought about individual "talents", the class selection process, or any other background on the students, apart from the school of their origin. Such additional teacher-sourced information was not relevant to the forthcoming classroom experience of computers. The focus was not on giftedness or talent, though it was precisely that factor which permitted the opportunity to run the classes. The tone of the day was creative extension work, therefore a unique opportunity arose to allow the students to freely explore multimedia construction, and remain centred on what interested them for as long as they wished.

Knowledge of the number of students from each of the schools contributing class members revealed the extent of initial peer support. The number of students from each contributing school are listed in *Table 4.2*:

| *Number of Students in the Class from the Same School* | *Number of Schools Sending this Many Students* |
|---|---|
| 6 | 1 |
| 4 | 1 |
| 3 | 1 |
| 2 | 3 |
| 1 | 3 |

*Table 4.2 : Number of Students from Each Contributing School*

Thirteen students came from just three schools. Three students were the only representative from their school, and therefore entered the class as "loners".

*Teachers* : The class teacher had run a similar gifted and talented class the previous year, and word processing had dominated computer work. The teacher was therefore looking for someone working with computers in a different way to assist her with the class in 1994. After a brief discussion about multimedia construction, she was extremely positive that the concept would be appropriate to extend the class with computers. Though the class teacher expressed a low self-concept with computers, she was highly supportive of their use.

The computer teacher who ran the computer laboratory at Koonawarra Primary School graciously exited the lab at 10 am each Thursday to allow the gifted class their hour with the machines. On special Thursdays, when other activities were occurring at school, it was possible to use the laboratory for longer than the hour. Such opportunities were usually known one to two weeks in advance. The class teacher was happy to allow the students more time on their computer project themes when these opportunities arose. Due to lengthy telephone conversations each week between the researcher and class teacher, collaboration and flexibility were high—a sense of team teaching prevailed.

The researcher was responsible for designing class activities, student groupings, computer use and media production within the "computer hour" each week. Computer use encompassed:

- knowledge of available Apple machines capable of multimedia production and construction
- awareness of machine speed, operating system and available memory (RAM and hard disk space) on each machine, so particular machines could be designated for use on low or high memory tasks
- loading and management of production software
- desktop organisation and backup of student resources
- connection of external storage devices
- management of floppy disk storage
- restoration of laboratory set-up at the end of each class. Desktops were left as they had been found prior to the class.

Media production involved the responsibility for audiovisual equipment, timetabling of production teams, and digitising of resultant video, sound and images. The class teacher, student assistant and volunteer parent supervised media production groups outside the computer laboratory.

In the first six weeks of class, when computer numbers were low, the Assistant Principal of Koonawarra Primary School kindly allowed the use of his machine each week for the duration of the class.

The Principal of Koonawarra Primary School was the ultimate support for the gifted and talented class, specifically offering the use of his school's computer laboratory and library facilities for the computer component of the day. No students from Koonawarra Primary School were in the gifted and talented class.

### 4.5.3 Resources

*People* : The student assistant was a reciprocal exchange student from The University of Massachusetts, Amherst, USA, currently enrolled in EDUM 221 then 212 in the Faculty of Education at the University of Wollongong. She requested the chance to attend the gifted and talented classes. It gave her a first hand opportunity to work with children in the medium she was studying. Her moral support, assistance with equipment, rapport with the children in the computer laboratory and expertise in drama and sound production contributed considerably to the class.

The volunteer parent was the father of a child in the gifted and talented class the previous year. He possessed considerable scientific knowledge, excellent video production skills, and was generous with his time and effort in support of the class philosophy. He continued the previous year's process of video recording class activities, and was willing to extend his expertise and support to take responsibility for the video production team when video recording was required.

The school librarian assisted the students in their search for information. Students then used the skills and knowledge of each other to express and edit ideas, especially once team work was in progress. In week 8, a friend of one of the students was a guest of the class. She was fluent in signing for the deaf, and went on to star in video production.

The researcher provided technical advice and HyperStudio® assistance when it was directly or indirectly requested (by report of another student experiencing difficulties). This technical or production advice was delayed long enough to allow students familiar with the required skills to offer their assistance first.

The class teacher provided the most significant support for computer project work. Her small group involvement during computer time allowed her to become very familiar with project content and specific student interests and talents, which she may not have discovered without this opportunity. As a "back seat driver" during the computer session, the class teacher was able to observe the students more closely than was possible in her regular role. She was then able to use this knowledge in the design of complementary class activities, to integrate the computer lessons in her overall class program.

*Machines* : A range of Apple computers in the Koonawarra computer laboratory were used for multimedia production, during the twenty seven classes. A core of four computers housed in the laboratory, plus two computers which were transported there each week (the Colour Classic belonging to the Assistant Principal, and the Parent's Machine), were available for the first six classes. Koonawarra Primary School purchased four new computers, which were available by week 7. The Assistant Principal's computer was not borrowed after week 7, so the typical number of computers available from week 8 was nine.

All computers in the laboratory were named and easily identified by large stickers across the top of the monitor. This facilitated student direction to machines, and also resource backup, through the use of a mental checklist. Computers were moved a number of times during the study, due to the school's purchase of new computer desks, so machine identification was even more vital. *Table 4.3* presents the details of all school computers used by the students over the 27 weeks of the study:

| *Model* | *Name* | *RAM (Mb)* | *Hard Disk Capacity (Mb)* | *Available from (Week)* |
|---|---|---|---|---|
| Colour Classic | Mel | 4 | 40 | 1... |
| | Ass't P's Machine | 4 | 80 | 1-7 |
| LC | Jake | 4 | 40 | 1... |
| LCII | Koorie | 4 | 40 | 1... |
| | Lorrie | 4 | 80 | 1... |
| LCIII | Parent Machine | 4 | 80 | 1... |
| | Richie | 8 | 80 | 7... |
| | Uno | 4 | 80 | 7... |
| | Tina | 4 | 80 | 7... |
| | Oscar | 4 | 80 | 7... |

*Table 4.3 : Computers Used by Students in the Koonawarra Laboratory for Multimedia Production and Construction*

In week 25, a PowerMac 7100 AV belonging to the researcher was set up in the resource room next to the regular classroom. It was used right throughout the day. The following week a PowerMac 6100 from the interactive multimedia laboratory in the Faculty of Education at the University of Wollongong was used in the computer laboratory, which was available for longer than usual. These PowerMacs, with 500 Mb hard drives and at least 8 Mb of RAM, were necessary by this stage—memory requirements of HyperStudio® were dramatically increased due to the need to create and run large animations which the students had produced.

Fifty floppy disks were purchased for student use by week three. Each student had two floppy disks to save and backup their early work They were responsible for collecting, managing, then returning their disks with the latest work at the end of the class.

Two external hard drives were used to supplement storage of group project resources as project material increased in volume— a 240 Mb drive and a 540 Mb drive. A cartridge drive was tested one week, but 40 Mb cartridges were of too little capacity to hold the resources of more than two groups.

Audiovisual equipment used for media production included a :

- Sony Super VHS video camera and tripod
- Canon Ion Camera and
- Marantz tape recorder

Most of the audiovisual equipment plus the hard drives, floppy disks and student group folders were transported to the class each week. Images were scanned and video and audio tapes were digitised for students by the researcher back in the interactive multimedia laboratory in the Faculty of Education at The University of Wollongong, using scanning and video digitising facilities already listed for EDUM 221.

A portable colour projection panel was borrowed from Audiovisual Services at the University of Wollongong for the "Show and Tell" session in week 27. The PowerMac 7100 AV drove the presentation, which was video recorded. Projection quality and subsequent video reproduction were poor, by comparison with the projection quality of the Sharp projector in the interactive multimedia laboratory.

*Media* : Students created their own video clips and audio files. They sought much of their information and many images from books, collector cards, calendars and magazines. Students requested the scanning of particular images from the following books:

*Sea Life*.(1992) Sydney: RD Press.

Alcock, A. (1988). *Horses Horses Horses*. Leicester: Galley Press.

Asimov, I. (1992). *Is Our Planet Warming Up?* Milwaukee: Gareth Stevens.

Baker, L. (1990). *Life in the Oceans*. Puffin.

BeckLake, J. (1989). *The Climate Crisis - Greenhouse Effect and Ozone Layer*. Sydney: Franklin Watts.

Blackall, B. (1990). *Young Players Rugby*. Sydney: Macmillan.

Bradshaw, J. (1982). *Animals in Action Giants*. ITV Books.

Carwardine, M. (1988). *Big and Small Animals*. Hove: Wayland Publishers Ltd.

Cheng, C. (1991). *Eyespy Book of Endangered Animals*. Ashton Scholastic.

Coldrey, J. (1981). *Harvest Mouse*. London: Andre Deutsch Ltd.

Davies, N. (1992). *Oceans Conserving animals and plants in a changing world*. London: BBC Books.

Dell, C. (1985). *Superbook Horses*. London: Kingfisher Books.

Edwards, E. H. (1991). *The Kingdom of the Horse*. London: Salamander Books Limited.

Edwards, E. H. (1991). *The Ultimate Horse Book*. Sydney: RD Press.

Hall, T. (1982). *Horses Down Under*. Sydney: Golden Press.

Ivy, B. (1988). *Our Wildlife World Tigers*. Grolier.

Ivy, B. (1989). *Our Wildlife World Zebras*. Grolier.

Kilpatrick, C., & Lambert, M. (1979). *The Living World*. Sydney: Field Educational Enterprises of Australasia Pty Ltd.

MacLeod, E. (1988). *Our Wildlife World Lions*. Grolier.

McCormick, J. (1985). *Acid Rain*. London: Franklin Watts.

Mead, H., & Fulwood, N. (1983). *Let's Learn About Animals... At the Zoo*. The Jacaranda Press.

Munn, C. (1994). *Winged Rainbow Macaws*. National Geographic, 185(1), 118-140.

Owen, R., & Bullock, J. (1992). *The Complete Book of the Horse & Rider*. London: Chancellor Press.

Papastavrou, V. (1993). *Collins Eyewitness Guides Whale*. Sydney: Harper Collins.

Petty, K. (1988). *Guinea Pigs*. London: Franklin Watts.

Rickard, G. (1987). *Focus on Diamonds*. Hove: Wayland.

Rodgers, F. (1991). *Animal Art*. London: Scholastic Publications.

Switzer, M. (1989). *Our Wildlife World Rhinoceros.* Grolier.

Taylor, B. (1992). *Coral Reef.* Sydney: Angus and Robertson.

Thompson, D. (1981). *House Mouse.* A. H. & A. W. Reed.

Ward, B. (1981). *The Ear and Hearing.* London: Franklin Watts.

Wilkinson, M. (1983). *The Phar Lap Story.* Budget Books.

The animal theme was selected by two group projects out of seven! Basketball cards disclose the nature of a third project. As student proficiency with the colour graphics tools in HyperStudio® improved, they were keen to complement or in some cases replace the scanned images with computer graphics of their own.

The "props" room next to the classroom assisted the students' imagination when it came to video production. The resources in this room were extensively used by two groups.

Sound production occurred either directly at the computer, or in another area where the tape recorder became an intermediate storage and testing device. In some cases sound production was scripted and rehearsed, and in others it was a matter of spontaneous production. The impact of sound was dramatic towards the end of available project time.

*Teacher Tools* : Teacher tools were of print, video and software nature. The print tools included:

- individual student skill checklists for resource production and HyperStudio® skills (see Appendix D)
- worksheets distributed in week 4 to stimulate brainstorming of ideas through the alphabet (see Appendix E), then across the interrogatives—who, what, why, where, when, how (see Appendix F)
- individual student manilla folders for resource collation
- group project envelopes for resource collation
- printed lists of scanned images from books for group project reference and planning (see Appendix G)

Video was used as a teacher tool on one occasion:

- A computer to video output of parts of the HyperStudio® tutorial, plus some aspects of a HyperStudio® project from EDUM 221, was recorded to present to parents and any students attending the information night on April 14, 1994. This evening was the parent introduction to the gifted and talented class.

A range of software tools were produced in HyperStudio® and in HyperCard®. Early stacks demonstrated functionality and displayed student resources:

- *Meet the Class, Picture Book Week 2, Picture Book Week 3,* and *Picture Book Week 4* - demonstrated the functionality of HyperStudio®, and presented an update of student resource production. Student photos from week 1 were scanned and featured in the first HyperStudio® stack the students saw. Each week, additional resources were displayed. In these early lessons the focus was on text, audio and scanning of student drawings.

Later stacks reflected creative student ideas and techniques back at the class:

- *Reflections* - presented a multimedia collage of HyperStudio® techniques and graphic styles which had emerged by week 8. Animation was one feature. Teacher compilation of student work permitted exchange of ideas and techniques in an inclusive environment which modelled respect for differences and creative expression.

As group project work developed, performance support tools emerged:

- *Themes* - a non-linear HyperCard® brainstorming tool developed by the researcher and based on the interrogatives, was used in week 9 with individual groups once project topics were identified. Following generation of student ideas, these were printed off for immediate and future reference.
- *G&T 5/6M* - a version of *Themes* containing all project themes with their ideas, was available from week 10 through to week 24. From week 18, a segment in the "What" section of each project theme titled "Resources to week 18", enabled students to view their collection of scanned images and video snippets. In some groups the numbers were considerable— the *animals* group had 66 images, while the *horses* group had 40. This HyperCard® stack showed images using the Picture XCMD, which required little memory. The inbuilt colour features of HyperCard® 2.2 (Color Tools) were too memory intensive for computers with only 4 Mb of RAM.

With separation of students into computer production and media production halves from week 11, it was necessary to draw the work of the whole class together to allow students to reflect on developments in student ideas and skills and see what other groups were doing:

- *CB G&T Group Overview* - presented a collage of students leading into a collage of images from group work in week 18. It gave students a feel for progress to date across the whole class.

Finally, a link tool was constructed for easy demonstration of the group projects in week 27:

- *Overview CB G&T* - permitted rapid access to any project, via a collage of project theme images with no titles. Once an image was selected, the next screen showed names and photos of the group participants and the books they had sourced for scanned images. Button selection then led either to view the project or return to select the work of another group.

Students were told that copyright issues precluded the use of any of this material for any other purpose than the learning it had assisted. A computer to video (S-VHS) output of a walk through all the group projects from the link stack was made by the researcher two weeks after the last class. Extra pop-up screens were produced for this demonstration, to act as sub-title screens. The S-VHS tape was then passed to the volunteer parent, who made copies for any other parents who requested a tape. This was considered the best way to enable parents to share what the children had achieved in the computer component of the class, without placing pressure on the students for product and performance.

### 4.5.4 Anticipated Process Outcomes

When a structured course program is required for management, student guidelines and evaluation, as in the EDUM classes, it maps to anticipated process outcomes. The following document written by the researcher represents the extent to which a program was constructed for the class teacher of the gifted and talented class:

> *"**Program** : The focus of the computer component of the day will be interactive multimedia. This is the incorporation of images, sound, text and some video clips in a computer program. Due to the interactive nature of this kind of computer production, only certain details can be pre-set. The interests and talents of the students will determine to a large extent the content and duration of particular exercises.*
>
> *The program to be used is called HyperStudio®. This program allows students to create individual cards (screens) containing information of text, image, sound and/or video nature. Screens are linked by the use of "buttons", which are active areas of the screen which respond when clicked on by the action of the mouse. Students can thus create their own programs with relative ease, and explore the different media as means to convey information on an area of interest. It is anticipated that it will not take the students long to learn the program. They will then be able to focus on topics of interest, group discussion and negotiation of*

*tasks and roles, collection of resources, construction of programs and presentation of this material.*

*At various times students will work in small groups, individually, or as a whole class. There will be ample scope for exploration and extension of different talents. Some may wish to follow one theme through for a lengthy period, while others may achieve several goals within the same time frame.*

*It is important to note that not all material needs to be produced on computer. For students with artistic ability, their drawings (in colour) can be scanned into the computer. Music can be recorded and incorporated as well as speech. Activities during other periods of the day may be documented by students who can use that as the focus of their program.*

*This kind of computer use aims to cater for a broad range of learning styles. Since part of the investigation is to see how students choose to use this production capability, not too much can be set ahead of time. There will be an initial exercise given to practise program use, but the direction following that will be largely up to the students. This is the significant nature of extension of gifted and talented students. Without prior knowledge of the group, inappropriate plans could be made. Adherence to these for the sake of a program could spoil spontaneity and group tailoring."*

From this document, the anticipated process outcomes included broad media production without an emphasis on computers, varied individual and collaborative exercises, topics based on student interest, and relative ease of student use of HyperStudio®.

## 4.6 Data Collection Process Across Classes

A range of data was collected across the two classes. The nature and format of the data varied with the stage of the course, the type of data required, and what other activities were occurring within the lesson.

### 4.6.1 Stage in the Course

*Early*—In the first class of EDUM 221 and G&T, visual and background information was sought from students as a starting point in the individual teacher/student relationships. In EDUM 221, student photos were taken with the ion camera, while students completed a pre-course questionnaire on paper (see Appendix H). The G&T students were photographed with a traditional SLR camera and interviewed in pairs about their perceptions of possible computer use, familiarity with computers and favourite media for expression. The pairing was for moral support to avoid any feeling of isolation at the taped interview, and also to allow students who were just getting used to the class to get to know a new peer in some detail.

In the initial classes which followed, formal class reports were written for EDUM 221, while student work was collected from G&T students, providing a summary of what each student had done. General notes were recorded in the stack *PhD Diary*.

*Middle*—The video camera featured prominently in the middle stages of both classes. It was introduced by week 3 in EDUM 221 within the context of a production tool, so further recording of typical classroom behaviour was less disruptive than if the video was introduced as a monitoring device. Due to the presence of the volunteer parent in the G&T class, video recording of classroom procedures was a regular occurrence, and the parent was happy to share any classroom footage he took. Since this included students at work in the computer laboratory, a unique opportunity was provided to see teacher and students at work from an onlooker's perspective.

The video recording of "Show and Tell" sessions in EDUM 221 was conducted to formalise the occasions and allow the researcher to focus on group discussion and the work presented.

At the end of the EDUM 221 course, the effective half way point for the full EDUM class, the fourteen students were given a questionnaire (see Appendix I) together with a stamped, addressed envelope. They were free to fill this in and post it at their leisure, or discard it.

By semester two, class notes for the second EDUM subject—EDUM 212, and the G&T class, were both recorded in *PhD Diary*. Relevant information was also transferred to one of two parallel HyperCard® stacks under the headings of:

- People
- Equipment
- General Information About the Class
- Follow-Up

These were functional headings which had emerged from class notes in semester one. They were geared for teachers who may wish to see the "nuts and bolts" of the classroom process. Considerable classroom variations had been noted across each of these practical headings. Data collection rigour and identification of patterns would be facilitated by the development of performance support tools for data compilation and presentation. Parallel stacks would also enable some comparison across classes.

Student work in individual tasks in EDUM 212 was collected, and all student work in the G&T class was saved as a vital backup measure, and a means of building a picture of what was happening from week to week with project work.

Specific individual interviews were taped with EDUM 212 students (see Appendix J) and the G&T class teacher (see Appendix K). The five EDUM 212 students were asked to reflect and offer thoughts and opinions on the EDUM 221 course and information technology use in general. The teacher of the gifted and talented class was asked for her perspective on the influence of the computer component of the class.

*Late*— Late in each course, student production work was the focus of data collection, particularly in the G&T class. The video was set up in the computer laboratory once student video production ceased, but the camera was just allowed to run, and capture whatever happened within its visual scope. Periodically, the camera was re-directed at another group of machines and students.

In the last weeks of both classes, production work was frantic. Routine class notes were recorded in *PhD Diary*, and appropriate sections were copied to the compilation stacks. There were extensive entries in the "Follow Up" section at this time.

### 4.6.2 Type of Data Required

The data collected by the researcher as part of the personal account could be broadly classified as information, opinion, observation, reflection or insight.

Information covered rough pen and paper field notes and student work. Rough field notes were recorded in sparse format on occasions when specific timing details, presentation order, student groupings or topic selections were vital to note precisely. These brief notes took minimal time and therefore allowed the researcher to observe interactions, listen to opinions, anticipate problems, and generally tune in to the classes very easily. Student work was either in electronic format, such as copies of sounds, images, stacks and movies , or in print or written format. Some of this material was process work, and some was assessment tasks.

Opinions were gathered by asking students directly, or they emerged in group discussions, which were crucial times to assess changes in individual and group attitude. Opinions were also sought in an anonymous way through the use of a HyperCard® stack. Each student in week 10 of course EDUM 221 entered their thoughts on digitising skills and the group project. Opinions made their way into regular class notes or video clips.

Observations were made in the natural course of classes, and frequently through the use of the video, to monitor the general flow of lessons in the computer lab. Video tapes were excellent for noting student concentration, persistence, and such interactions as who "dominated the mouse". Class observations and information were recorded as detailed field notes in *PhD Diary*, usually on a daily basis, or placed directly into one of the performance support stacks. With constant practise, this process of visualising the class and recording as much detail as possible became quite lengthy. It was surprising how much detail could be remembered by viewing the student work which had been backed up.

Reflections were included by the researcher at the end of each class report for EDUM 221. They demonstrated thought processes and reasoning behind changes in classroom organisation, or response to the difference between what was anticipated and what actually happened in class. More general reflections were found throughout *PhD Diary*.

Insight is a personal realisation of patterns or connections between previously unrelated aspects of knowledge or experience. Sometimes it is like the "aha" experience of creativity, and at other times patterns emerge through effortful working and re-working of data from different perspectives. Analogy and metaphor feature highly with insight, so cross-fertilisation of different aspects of life stimulate insight. The multiple themes which emerged in the richness of *PhD Diary* were the source of considerable insight, which was often expressed in the process sub-theme "Central Ideas".

### 4.6.3 Unusual Classroom Circumstances

With whole class sessions, the whereabouts and activities of all students and support staff was noted. When G&T classes were broken up into groups which occupied different areas, it was necessary to ask the support staff what students in their care had accomplished and whether any notable events had occurred.

Several notable events interrupted the normal flow of particular classes. The first class of EDUM 221 was run in a multimedia laboratory with no power. There was a campus wide power failure. This made for a realistic introduction to the down side of the use of technology. In the G&T class, from week 13 to week 15, Computer Newsday interrupted the flow of project work. During weeks 13 and 14, the media production groups continued their project work, but the groups assigned to the computer laboratory used whatever machines they could to word process stories for Newsday. Week 15 was Computer Newsday, organised by the district computer co-ordinator. This day provided students with a rich experience in newspaper production to meet a deadline!

## 4.7 Data Analysis and Presentation

Cashman and McCraw (1993) discuss data collection and analysis procedures, referring to field notes, which:

> *"...consist of detailed descriptions of the setting, events, and interactions of participants. They also provide a place to record the researcher's ideas, reflections and interpretations of the observed events." (Cashman and McCraw, 1993, p210)*

The organisation and coding of field notes is described by Cashman and McCraw as a very individual process, which may follow chronological order or "follow themes that have emerged during the collection process". *PhD Diary* permitted the maintenance of both chronological and thematic records within the one electronic document.

When discussing data analysis strategies, Cashman and McCraw (1993) suggest:

> *"Most researchers find it useful to look for themes, strands, incidents and commonalities in the data as it is collected. Developing metaphors and analogies may help the researcher analyze the data." (Cashman and McCraw, 1993, p211)*

The development of the garden metaphor for the CD-ROM representation of the research data and the analogy of the teacher as gardener greatly facilitated the structuring and exploration of this data in the study.

## 4.8 Anticipated Similarities and Differences

The more aware the senses of the researcher, the more finely grained the picture which they produce. The more aware the researcher is of personal biases, the more a reader can take these into account, and confront their own biases. The following anticipated similarities and differences represent biases which the researcher as teacher carried into the classes.

A constructivist teacher assumes every group of students will rapidly develop a unique identity with a range of idiosyncrasies. This influences the teacher's subsequent design of their environment. Hence no two classes, irrespective of the similarity of objective student characteristics, will ever be the same. This responsiveness to student needs can be finely tuned to a cyclical modification of classroom circumstances with each lesson. It requires great awareness of student perspectives, and close monitoring of what actually happens in class in relation to what was planned.

Bearing in mind such class individuality, there would be few anticipated similarities between these classes.

### *Similarities*

The same teaching philosophy would be applied to the students in both classes— appreciation, respect and identification of student perceptions and ideas. The constructivist teacher would observe students closely for behaviour patterns, note their work, and seek feedback either directly or via the comments of friends. The concern would not be whether students had picked up the ideas of the teacher, but what ideas they had generated from the learning environment.

The teacher as researcher would be more intensely aware of all happenings—of student responses, of the effects on the class of varying strategies, would be very interested in student comments and very in-tune from one class to the next with what had happened previously. The fortuitous timetabling of both classes on a Thursday would mean they could be seen in parallel, and lessons learnt from either class could transfer to the other class if and when appropriate.

The teacher as designer would constantly use the information gained as researcher to tailor the next class to student needs. The outcomes of the design process would be in terms of classroom organisation, student groupings and tasks, and print, video or software tools to facilitate learning. Most "disposable software" would be designed between classes in response to an identified need— to reflect student work back at the class, to share strategies, to actively encourage free exploration of ideas, or to further student skills in production and knowledge construction.

### *Differences*

Obvious differences between the classes would be in terms of student age and social and intellectual maturity on the one hand, and the influence of curriculum and evaluation requirements on the other.

Having acknowledged these researcher biases, the researcher then conducted the classes and systematically record what happened. Two lenses were required on the researcher's perceptual camera —

- a wide angle lens to discern broad patterns of interest to the research community
- a telescopic lens for sensitivity, to relate the experience to the teaching community

# Chapter Five - The Classroom Experience

## Introduction

At a superficial level, in keeping with constructivist principles, the process outcomes of interactive multimedia design (production and construction) were specific to each group of students (EDUM and G&T). This would be the case for any class. However, when data processing permits construction, reflection and analysis, it is possible to identify some emerging similarities and differences across classes.

Each class is discussed individually, prior to the exploration of common themes. The location of data weaves its way between thesis and CD as indicated in *Table 5.1* and *Figures 5.1* (p135) and *5.2* (p172):

| *Class* | *Aspect of Class Theme* | *Thesis* | *Garden Location* |
|---|---|---|---|
| *EDUM 221* | • Student Preferences | 5.1.1 | Figure 5.1—A |
| | • Class Process | 5.1.2 | Figure 5.1—B |
| | | Appendix L | Figure 5.1—C |
| | • Product | Appendix M | Figure 5.1—D |
| | • Process Outcomes | 5.1.4 | |
| | • Opinions and Reflections | 5.1.4 | Figure 5.1—E, F |
| | • The Process of Group | 5.1.5 | Figure 5.1—C, G |
| *EDUM 212* | Collaboration | Appendix N | |
| | • Student Thoughts and Ideas | 5.1.6 | Figure 5.1—C, F |
| | • Major Projects | 5.1.7 | Figure 5.1—H |
| | • Resources and Process Outcomes | 5.1.8 | |
| *G&T Class* | • Class Process | 5.2.1 | Figure 5.2—B, C |
| | • Products | 5.2.2 | Figure 5.2—D |
| | • Patterns of Resource Use | 5.2.3 | |
| | • Process Outcomes | 5.2.4 | |
| | • Opinions and Reflections | 5.2.4 | Figure 5.2—A, E |

*Table 5.1 : Location of Class Data Across Thesis and CD*

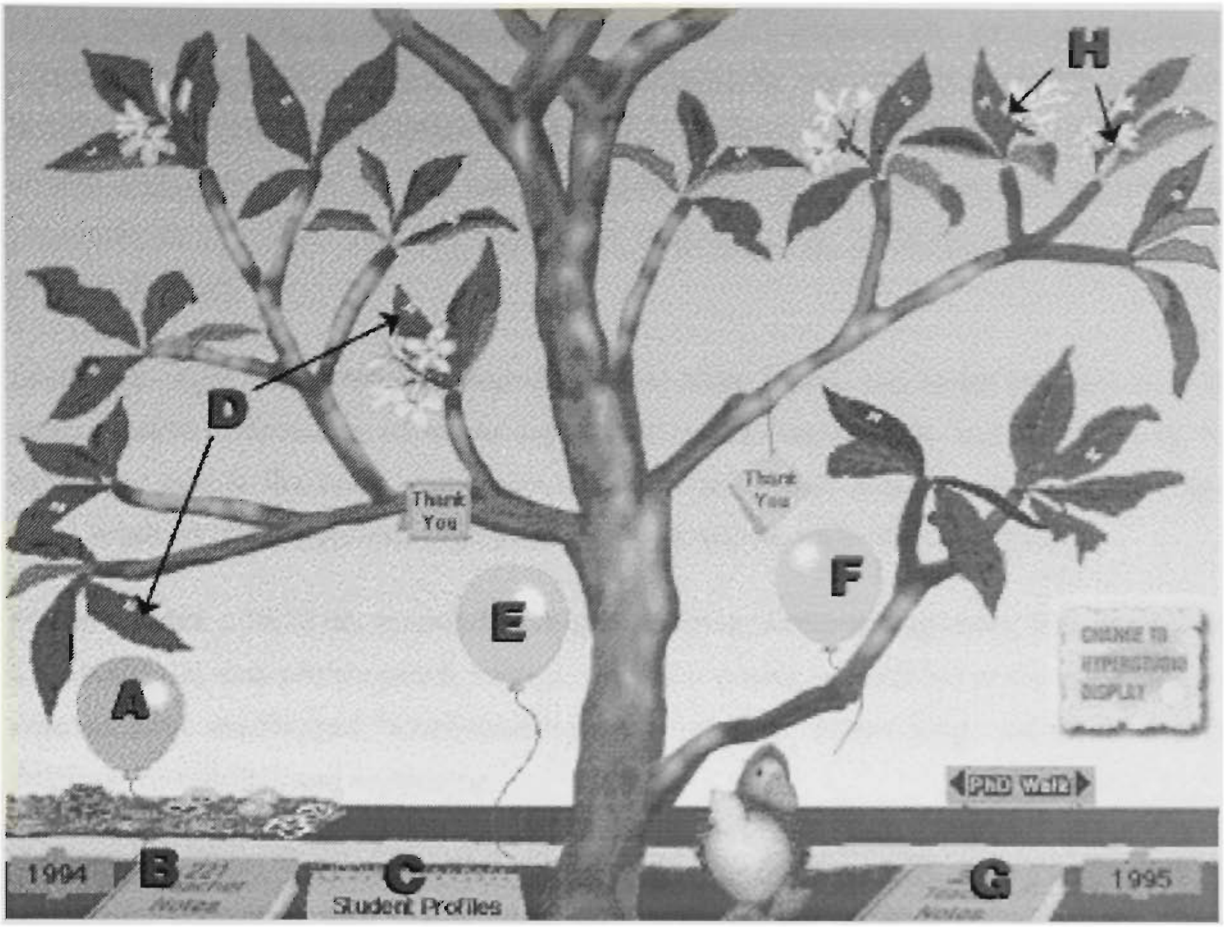



*Figure 5.1: EDUM Map Showing Class Data*

KEY:

| | |
|---|---|
| A - Student Preferences | E - Student Opinions |
| B - 221 Teacher Notes | F - Student Reflections |
| C - Student Profiles | G - 212 Teacher Notes |
| D - 221 Student Projects | H - 212 Major Projects |

## 5.1 Class EDUM— Pre-Service Primary Teachers

## EDUM 221— Information Technologies and Multimedia

This elective subject was conducted in Semester 1, 1994, with fourteen pre-service primary teachers in the Bachelor of Teaching in Primary Education program. The co-lecturer conducted a lecture/demonstration in the computer laboratory in the first hour; the researcher guided students in practical work for the remaining two hours. Some weeks practical work occupied the full class period. This was the introductory elective in interactive multimedia.

### 5.1.1 Student Preferences

In the individual responses to the questionnaire (Appendix H) that students completed at the beginning of the first class, they expressed preferences with respect to learning style, project work, group size, preferred mode of expression, work organisation, concept development, problem solving and reasons for course selection. Answers have been summarised and synthesised to present the range of comments, or analysed and coded into categories. In the latter case, numbers for a category of response are presented in brackets. The full individual responses can be browsed in *The Garden* (*Figure 5.1—A*).

*Learning Style* : Responses to learning styles were broad, encompassing not only the more passive orientations of media input preference, such as listening or watching, but extending across the active spectrum with the addition of diagram drawing, talking it over, working with material, experiencing the situation, reflecting and talking.

*Project Work* : Students sourced information from libraries, Internet, magazines and CD ROMs. It was photocopied, hilited, then key points or detailed notes were written. One student mentioned brainstorming after reading. Processing continued via re-drafting, re-reading and re-writing.

*Group Size* : Nine students were happy to work either individually or in groups with the qualifying statement that it was important to know and trust group members. Three students preferred to work individually, giving reasons such as difficulties organising groups out of class time, possibility of the load on one person, and desire for complete blame or credit for performance. Two students expressed strong support for work in pairs or groups for the motivational and communication benefits.

*Preferred Mode of Expression* : Positive responses were noted for essays (6), speech (3), projects (3), computer presentations (5), research papers (1), plays (1) and audiovisual support (1). Negative responses were also expressed for essays (2) and speech (3).

*Work Organisation* : Twelve students indicated they re-accessed past work. Nine of these students stored their work electronically. Folders or filing cabinets were also mentioned.

*Concept Development* : Eight students stated they re-accessed work to re-purpose it and link with other themes. One negative response indicated future intention ("not yet").

*Problem Solving Style* : Three students preferred problem solving where the outcome was a single answer. The remaining students were happy to generate many solutions (8) or work with either type of problem (3).

*Reasons for Course Selection* : The general categories encompassed improved employment opportunities (4), personal interest in the technology (6), perceived benefits for classroom teaching (8) and a feeling that this type of technology was the way of the future (5). Six responses listed only one of these factors. The rest were multi dimensional.

Questions on evaluation, computer use and software experience required check box answers:
*Evaluation* : Equal numbers of students favoured predominantly mastery or predominantly grading evaluation. The preferences for markers were single (6), group (7) and peer (1).

*Computer Use* : Students were either happy to use computers for final work (4), used computers frequently (5), or couldn't live without computers (6).

*Computer Experience* : All students were familiar with word processors, spreadsheets and games, most had used databases (13) and graphics packages (12), while programming (4) and specific work packages (2) were largely unused.

### 5.1.2 Process and Products

A brief description of each laboratory session from the teacher/researcher/designer perspective is listed in Appendix L. Detailed teacher notes and student profiles are available in *The Garden* (*Figure 5.1—B,C*).

On reflection, the fundamental class activities which combined in various ways were:

- discussion of instructional design theory
- demonstration of software examples
- demonstration of construction skills either live or on video
- demonstration of digitising skills to a panel of subsequent "experts"
- individual resource production
- individual and paired skill development
- reflective technical sessions
- individual and paired completion of construction tasks
- "Show and Tell" sessions for completed tasks
- comparative discussions on HyperCard® and HyperStudio®
- group discussion on a major project
- group collaboration on resource production and compilation

Theory on instructional design included discussion of the process as a move from needs, tasks and learners to metaphor, strategy and interaction. In the broader view, the process could be seen as analysis, design, development, implementation and evaluation. The question episode was examined as a key interaction in much "educational software", and the group project was explained as a sequence of problem definition, creation of a design brief, production of a storyboard, development of a prototype and realisation of a final product. The co-lecturer presented this sequence over the first eight sessions, in parallel with practical skill development in digitising and multimedia construction, which were run by the researcher.

Most students were completely unfamiliar with the design process. (The cognitive load of production skills was far too great to expect translation of this theory into immediate practice with their individual or group projects.) Students rapidly developed the ability to critically evaluate demonstrated software in terms of interface design principles. They became very critical of commercial software products demonstrated, and were able to explain clearly what they felt was wrong with design elements and how they would deal with these problems, given a team of production experts.

The application of these interface design principles to software production was a different matter— it represented a separate set of skills at a different level of expertise. Without experience of particular production problems, students could not anticipate and easily overcome practical difficulties to express more abstract design principles. That did not mean they did not understand the design principles in someone else's program. It was questionable, however, whether most students wanted to mould their production to pre-conceived design. This objective promotes problem-solving in production skills, driven by the perception of "good design", but does not emphasise content knowledge. The focus is on the detail of the window frame, rather than what will appear in the window.

The range of strategies used to demonstrate various construction skills— from silent video to video recorded live demonstration—provided some interesting insights. Silent video forced students to watch very closely and look for patterns. Early cognitive overload, indicated by fidgeting and movement, was followed by settling and anticipation of the next mouse movement once the pattern of production of basic elements like buttons and fields and resource addition was seen in HyperStudio®. When asked if they would like a live demonstration to consolidate the video, students were confident to overlook this step and move straight to the computers to try for themselves, assisted by a detailed set of tutorial notes. The necessary practice of pairing students, due to moderate machine shortage, was fortuitous. Many students opted to work in pairs on subsequent occasions, even when the opportunity for solitary work was provided.

The decision to run different groups of students through resource digitising, to become the group "experts" in video or sound or image digitising, was beneficial. One teacher could not be in several places at once. These student teachers would be in the teaching role in a classroom, so the relevant skills they required were twofold— not only the ability to digitise video, for example, but also the ability to teach others the same skill. People of high technical competence are not automatically teachers—they require the communication skills to share their knowledge, and the interpersonal skills to allow the learner to feel comfortable in the situation. The constructivist philosophy places the feelings of the learner above the technical competence of the teacher. The generation of a group of "experts" meant other students had a panel of assistants to approach for advice on individual resource production, in addition to the teacher. Any of the experts may be available at different times, and may offer an alternate means of explanation.

Reflective technical sessions usually occurred at the beginning of the practical time in class. They demonstrated the latest technical findings, such as crucial settings on particular machines, or specific format requirements, in order to prevent the recurrence of problems. These demonstrations with group discussion permitted review of earlier material in the light of new knowledge, and the opportunity to integrate new knowledge as the range of skills became more diverse yet globally interconnected. Students were often impatient to get to the computers, and these technical discussions were frequently not appreciated until the problem situation was faced. Then loud comments of "Oh! That's right! I need to..." could be heard. The information was now relevant. Others had discovered these problems in the course of common exercises. The class demonstration meant a panel of peers was available to problem solve for others when difficulties arose. Knowledge was not held in one head, but shared. The diagnosis of someone else's problem could be as powerful for learning as the personal experience. Since some machines could be physically moved, and settings changed, it was not practical to stick instructions or findings on the walls. Students were also not geared to availability of electronic performance support— they wanted to ask a person if possible.

The completion of the HyperStudio® tutorial then initial construction task in pairs was popular with students. In both instances, they were provided with a set of instructions, but were free to explore and create their own interpretations if they possessed the necessary skills. The responsibility was shared, diverse talents could be complemented, and the need to explain actions to a partner promoted verbal expression, consolidated knowledge, and exposed misconceptions. The HyperStudio® tasks focused on the relationship between stack structure and content. Students had to build the structure then add the content. Expressive freedom emerged through graphic, text and sound content elements. Student pairing provided the confidence to "bend the rules" through shared responsibility.

The "Show and Tell" sessions focused maximum attention on any task product so technical knowledge, production strategies, problems and experience could be shared. It was important for students to present their work and verbalise new vocabulary. Others could view the work and suggest alternative applications of the design, or further design developments. The group atmosphere was collaborative and supportive at a fundamental level, due to shared experiences, but superficially tempered by humour and competitive banter. Many of the problems which raised the most laughter were those which had been widely experienced or personally witnessed. Freedom to laugh about problems led to open discussion about production and construction issues. No-one was seen as a universal expert, though individuals established profiles of expertise in certain production areas. The video recording of Show and Tell sessions valued student effort by extending the potential audience beyond the laboratory. At the same time, students were protected from the overly critical comments of an audience which may not relate to production difficulties.

Comparative discussions on HyperCard® and HyperStudio® emerged with the HyperCard® tutorial. It was important to note similarities and differences between the two multimedia construction applications in:

- object properties
- scripting functionality
- required resource formats and
- memory handling capacity.

The specific resource format requirements of HyperStudio® were discussed immediately before HyperCard® was introduced, to avoid confusion. A performance support stack for HyperCard® was constructed so students could build a HyperCard® tutorial stack parallel to the HyperStudio® tutorial stack with relative ease. By standardising this task, and simplifying the addition of coloured images, movies and sounds to a HyperCard® stack via a media palette, the structural and scripting power of HyperCard® was readily apparent. Subsequent tabling of resource format requirements of HyperCard® consolidated the comparison.

The breadth of the tutorial task in HyperStudio® and HyperCard® was enough to help establish a concept of the global functionality of this category of software. The extension of basic HyperCard® functionality with the media palette was justified on the basis that improved colour handling capacity and ease of media resource connection were emerging trends in the development of multimedia construction software. It was anticipated equivalent functionality would be provided in future upgrades of HyperCard® or its competitors. The emergence of Oracle® Media Objects has validated this move.

Scripting was a major barrier to expression of design principles in production work. While students frequently lacked the ability to write a script for themselves, they knew exactly what structure and interactivity they required and were very capable of explaining this to an available scripter. It was soon obvious the sophistication of individual student design capability could not be assessed by production and construction tasks, or ability to write a design statement. Design capability encompassed the whole process, from technically unrestrained conceptualisation of a program, through resource production to practical construction, layout and interactivity, which relied heavily on scripting if much of the conceptual design was ever to be realised.

*Individual HyperCard® Projects* : The creativity, potential and diversity of design in the individual HyperCard® projects was exciting and rewarding for students and teachers. A summary of each project is presented in Appendix M. The actual projects may be accessed in *The Garden* (*Figure 5.1—D*).

Neither the students nor the researcher expected the range of interests or the variations in screen design which emerged. Despite student criticism of professional products for minor inconsistencies in interface design, the same critical eye was not self-directed. Students wanted to express their individuality. The activity was not only a demonstration of skill development, but also a playful means of expression which presented scope for humour.

*The Group Project* : The attempt at a group project was provided to allow the students to experience what is more common in multimedia production— a larger team. Students were initially reluctant to consider the generation of a product which represented all their ideas when the process was instigated. The initial brainstorming session was left until week four, so students could view a range of multimedia products, develop some resource production skills, try some construction designs in HyperStudio® and generally increase their awareness of the breadth of possibilities for a group project. The co-lecturer introduced the group project with a discussion of process, which resulted in the following summary on the whiteboard:

- Select Groups/Teams

- Problem - what is the problem? Basic Ideas; Aims and outcomes? Audience? Limitations; Resources available
- Standardise: Overall Structure and Common elements. All this $\Rightarrow$ the design brief.
- Strategies would be sought for presentation; Allocate roles and tasks: Research background ideas/information; Categorise. All this $\Rightarrow$ storyboard.
- Collect resources - Pictures, movies, text, sound files; Create resources (based on decisions of common elements)
- Products developed along the way here would be the structural prototype (demonstrating strategies), collections of graphics, digital video, sounds and text files. These slip together in the prototype, which would then be evaluated, modified and refined to create the final product.

The co-lecturer then requested the group brainstorm some themes for the whole group project. The following were some of the titles put forward:

> Australian Identity, Business studies, Environment, Convicts, Great Barrier Reef, Anzacs, Local area, Computers, New Constitution, Water, Holidays, Tourism, Great Battles, Keep World Peace, Politics of Social Justice, Surf Life Rescue, Using Computers, Abusing Computers, Games, Simulations.

The last two were circled as strategies rather than themes. The target audience was unanimously chosen as years 5-6. The request to categorise ideas produced the headings Environment, History, Geography and Technology, then the general rumble of "KLA's". Students broke up into four groups for discussion, then presented the following ideas:

- Group 1: The local area - Belmore basin. You could look at the history, geography, commercial uses, how humans affected it and the wildlife.
- Group 2: An Australian walk through, focussing on environment, humanistic views, an exploration of points of interest and discovery.
- Group 3: Michael's idea of Peace in the World - an interactive game or simulation. The user would take on the identity of a powerful figure such as a UN official or a GreenPeace member or a protester. They would be presented with scenarios, and would have to make decisions on how to respond to the situation.
- Group 4: Australian Identity, loosely based on a school project. It would start in the classroom, progress to the local area, the mall etc. The student could pick up resources and they would be given tools to allow them to create their project.

The co-lecturer summarised the strategies as a visual world view exploration, a game, a constructed response and a local view. All these ideas should not be lost. While they may not be used as they were, they represented strategies that could be applied with different content. The co-lecturer left the students with the following task for next week:

> *"Think through the ideas you just presented, and think about the others. Mull over and throw these ideas around in your personal think tank and come along next week ready to justify your position."*

In week five, one student wanted to stay with a game idea, while another was concerned that a whole group task would squash the creativity of the individual. The ideas still centred around the Australian Identity and a game. Students were asked to split into these groups to further define their tasks. The following ideas were generated:

- The *GAME*: (8 students) This would be based around industries, schools and other community services, shopping centres and residential areas. The user would have limitations such as budget, access for groups (eg an ambulance needs a fast route) and geography (don't put a road through a swamp).The aim was to build a transport service. It would work within a geography metaphor and the user would have feedback at each step.
- The *RESOURCE PROJECT*: (5 students) The purpose of this would be for the student to build their own idea of the Australian Identity for the 2000 Olympics. The narrower goal would be what kind of things they would like to see at the opening ceremony. The student would start in the classroom, and would leave to visit the mall, talk to taxi drivers, visit a church, council, library and newspaper office. They could view other opening ceremonies and see how others did it. They could access historical data and statistical information about the population profile.

The issue was not resolved and the game group started talking about their desire to split. The researcher asked if they were happy to split in two and use the same game structure with different content. There was disapproval voiced over trying to link the two groups in a central theme "just for the sake of it". A student suggestion to link the two through the game concept of building the road service for the Olympics brought smiles of agreement.

Discussion began in week seven with the resource project group. What content did students wish to include? Where would the user visit? Responses were pinned down to:

- The Library - full of books, videos, newspapers, audio/video CDs. Content would cover history of the Olympics, population statistics and history of the development of different cultures in Australia

- The Mall - many people would be interviewed—the user could click on images of people and hear their comments
- The Airport - Flags would be up on a wall—the user could click on a flag to access visitors from different countries

Discussion then continued with the game group. Many ideas had been expressed, some of which were only workable with complex programming. The researcher asked what content the students wanted the user to pick up - or what objectives the game had. At this stage there was much disillusionment with the game idea, as it did not seem to be compatible with the class project. If the resources for the game were housed in the Library, wouldn't the user feel disoriented coming out of the computer game only to find themselves in the library? The researcher mentioned the games had two themes - one of which was building a structure, the other was using an existing structure most efficiently and having to make decisions based on available knowledge. One student suggested the latter was more workable, to which the researcher replied that the skills of map reading, checking timetables, working with a budget and so on were very worthwhile. The concept of a high score table was mentioned by students as a motivating inclusion.

Now the two arms of the program seemed to be developing, the issue of interface had to be settled. Was the game still in the computer or not? Student suggestion—the same environment could be used for both. The possibility of using the same environment for both raised the issue of how the user approached this - they would have to make a decision at some point to play the game or collect information for their project.

If they decided to play the game, the panel which came up along the bottom of the screen would contain their budget counter, score card and other appropriate facilities. If they decided to collect project information, the panel along the bottom would contain their notebook and printing facilities.

The researcher stressed that now was a good time to organise people for resource collection. Certain screens would start to take shape as content was generated. Students were allocated specific resource production roles, specifically for the resource project arm, which was currently the most tangible.

In week nine, a busy production week, the last half hour was devoted to the group project. One student who was proficient in programming, and who had accepted the task of developing the main interface for the group project, demonstrated his stack. The first screen, with animation and movie, challenged the user to decide between the project and the game. Selection of the game produced the navigation system—a stylised image of a sidewalk, which scrolled horizontally according to mouse selection of a left or right arrow. As yet there was no definite structure for the game.

Following the successful HyperCard® "Show and Tell" in week ten, week eleven was full production mode for the group project. The researcher demonstrated the stack "Background", a full-screen black and white stack which was produced to show students how all the previous HyperCard® work they had done could be seamlessly incorporated in the group project, as examples of Australian CDs in the library. Students were asked which group they would like to be in - the mall, the airport lounge, or the library newspaper, video or audio sections. The lab then swung into full production. This was the time students gained the opportunity to digitise resources for a common goal, and apply their skills and problem solving with real group support. The Canon Ion camera was introduced as a quick source of portrait images. Notable was the series of video recorded interviews in which eleven students role played travelers from different countries. The friendly atmosphere and group cohesion was memorable.

Students demonstrated great production proficiency— they worked with template stacks or generated new HyperCard® stacks, digitised video and grabbed stills, processed images through PhotoShop, recorded sounds, used HyperStudio® for its paint tools, used ClarisWorks® for the spreadsheet facilities, and exhibited much greater proficiency with the network and management of resources than they had previously.

### 5.1.3 The Influence of Resources

*People* : The teacher/researcher progressively withdrew technical support from students as the course progressed. In the early classes, all machines were running prior to practical work, and appropriate folders were open ready for students to simply double-click on the coloured icon. As classes progressed, students were instructed as to the whereabouts of applications or examples. The researcher's absence one week delayed the evaluation of "expert status". Students were forced to rely on each other, and experienced another week of practice prior to testing. By the end of the course, the researcher was no longer worrying about machine status prior to a class, as machines were often already in use by students.

With the development of student production skills, the students began to collaborate and use each other as resources for technical support, creative input, advice and feedback, and literally as a human resource for program content— someone to interview, someone to make that special sound effect or someone to photograph as a character. This student reliance on other group members was very important for exposing character traits and strengths which were not evident in a less practical environment. Different abilities and perspectives were valued for their contribution to a pool of skills and ideas.

*Machines* : Students initially used the same machine from one week to the next, but as resource production required them to move to specialist machines, they were forced to become more versatile and select a machine according to their production needs and the needs of others.

Resource production raised issues of organisation and resource management. There was considerable confusion in the first few classes about the whereabouts of resources and problems with version control of programs. Students gradually became aware of the need to move not only their main stack, but also the resources they had linked to the stack when they used another machine. Changes were often made in one copy of a stack, then another copy subsequently opened. Failure of the latter stack to reflect the alterations was met with horror. Through the experience of these problems, students were introduced to the need for naming protocol, file management, and the purpose behind back up of latest work to the server.

The video camera was seen as a practical class companion once it was used to record the HyperCard® tutorial for absent students, and capture the "Show and Tell" sessions. The initial shyness of students decreased as the camera was used for production work, particularly the work for the group project interviews in week eleven. At the final demonstration of the group project, students expected the display to be video recorded, and took charge of camera set-up.

The scanner was a very popular piece of equipment, and image scanning was a skill which contributed significantly to student self-confidence with the technology. The ability to obtain and visually manipulate quality graphics was exciting for even the most reserved individuals, who were still noted to release the odd "Ooooh, look at that!"

The Canon Ion camera was only used once, but to great effect for the group project. The speed of production was very popular for rapid prototyping and dealing with last minute needs under time pressure. Image quality was a disappointment.

Video digitising was a much more complex process than sound or image digitising, and involved many vital steps in a particular sequence. Students did not mind the number of steps if conditions remained unchanged, but on several occasions the required software was not functional, or machine connections were altered for project work, or hard drives were full so movies could not be captured. Movie compression was very time-consuming, and ultimate video quality was disappointing to students, so in general, video was not a resource widely sought by them. While they enjoyed producing the video footage, the digitised results did not seem to be valued highly by students. However, students stated that they were pleased that they had mastered the skills.

*Media* : Books, pamphlets and general print resources were heavily used as sources of images for scanning. Colour prints from home photo albums were a source of copyright free material.

The inclusion of a video clip was one of the requirements of the individual HyperCard® task, to demonstrate video digitising skills. Most students, therefore, digitised whatever material they could access most easily— often it was home video tapes. The material was not necessarily the most appropriate for the project. Students felt the focus of video production was on skill development in a multi-step process. Later, video material required for the group project was produced by the students, with the students and for the students.

*Teacher Tools*: Print material was of immediate use in class, to guide students through an activity, indicate general class plan, or frame a discussion. It was particularly beneficial when students were late or absent. The collection of print material was a good summary of course content and activities for later reference.

Video tapes were effective teacher tools. They could be shown again at any stage for reflection and comparison with later techniques. Silent video focused attention on visual detail. Many students learn about computer use by watching others— they don't need a running commentary. Audio was vital when a live demonstration was recorded, since the discussion of problems in this instance often dictated what was demonstrated.

Software tools to link, model and reflect student work or technical details were appropriate for interactive demonstration, instead of hypothetical discussion. They also focused the teacher on what issues were to be covered.

The performance support stack for the HyperCard® Tutorial was effective, and the student response to HyperCard® was positive. Students seemed pleased with the power the scripting gave them. They were not content to leave the movie where the script put it, and alteration of the script-driven animation by one student merely sent a challenge out to the others. With the support stack, students had immediate navigation support through the palette, they could see what card they were on and the total number or cards, they had received a live demonstration during which they could ask questions, and they had the prior experience of HyperStudio®, so the concepts of button. field, browse and graphics tools were no longer new.

Past researcher experience of HyperCard® demonstrations at interactive multimedia workshops supported the use of advanced functionality in introductory exercises. Colour was a vital feature, and ease of addition of images, movies and sounds provided the chance for the students to focus on content and media orchestration rather than the tool. Normally, with the HyperCard® application, the creation of a new stack results in a single blank card with no functionality. When beginning from this empty screen, there is little a student can achieve in one sitting to warrant further interest in HyperCard® as a tool for interactive multimedia construction.

When media addition was facilitated with the support tool, students in EDUM 221 were able to explore the scripting power of HyperCard®. While this was not a true representation of HyperCard®, the researcher justified its use on the basis of software development trends.

### 5.1.4 Process Outcomes, Opinions and Reflections

#### Process Outcomes

In addition to the fulfillment of EDUM 221 task requirements, which warranted development of production and construction skills with interactive multimedia, the researcher felt students developed many social and professional skills, and expressed feelings of satisfaction with their level of mastery of the technology.

Students demonstrated competence with resource digitising both in organised skill development sessions, and in subsequent application of skills to resource production for the group project. Production for the group project was under time pressure. This forced students to select resource production in their area of greatest skill or confidence. When problems arose, however, they could turn to any number of helpers, since all had experienced each required skill in their individual project.

Students demonstrated awareness of similarities and differences between HyperStudio® and HyperCard® in their positive response to the HyperCard® tutorial, and the discussions which were generated by comparison of resource formats for each application. The researcher was not able to determine student ability to transfer this understanding to a third example of an interactive multimedia construction application. The students would probably face this test of transfer in schools.

A range of applications for resource production and interactive multimedia construction were experienced by students during the course. In the early stages of skill acquisition, students were focused on selection of application settings to achieve a specified outcome. With growing confidence, students began to experiment with settings, and to utilise alternate applications to give comparable or superior results. This transfer of application functionality seemed to give students a definite sense of control over the technology, through choice. They were able to decide what functionality they wanted, then use the best application to obtain those results. The output of one application could then be cycled through another for additional effects.

The immersion of students in the interactive multimedia laboratory assisted the transition from relative information technology novice to competent interactive multimedia producer. For the third year students this progression was slower, but the ultimate outcome was no less dramatic. The delay between teacher demonstration and first hand student experience was minimised, when compared with a format of separate one hour lecture and two hour practical. In addition, students were able to use the predominantly postgraduate interactive multimedia laboratory during their free time most days before 4.30 pm. Such flexibility of access was important for skill consolidation, student interaction, and student/teacher communication.

Student concern over assessment criteria emerged in a number of situations in a variety of ways:

- reluctance to involve themselves in the group project when things did not go their way (I don't want to get a mark for something I don't agree with)
- irritation at the end of the HyperStudio® task when all pairs achieved the mastery grade despite differences in sophistication of stacks (mine is better - why don't I get a higher mark?)
- concern that all digitising skills were not of equal difficulty
- annoyance in graded tasks when those students who had put a lot of effort into the task raised the standard of the grading

These student teachers would be going out into classrooms to establish a range of learning environments with varied assessment strategies. This course provided them with an opportunity to reflect on their own feelings about assessment methods which they espoused as teachers.

The principles of interface design were absorbed very rapidly by students. This was interpreted from their ability to critically evaluate commercial software packages. With a "designer's hat" on, they could spot interface inconsistencies, recommend alternate structures, relate to comparable instances in other programs, and interpret interface conventions to use the programs.

The ability of students to implement the design process reflected the combination of many skills at a high level of complexity, and demonstrated the difference between knowing "that" and knowing "how"— declarative and procedural knowledge. Conditional or contextual knowledge would only be obtained by repetition of the whole process a number of times. The design process was discussed in week four, and could have been applied by students to their individual HyperCard® project, and to the group project. Students could experience the difference between operating as the individual in complete control of all aspects of production, and the individual immersed in a cooperative exercise, where group needs were the dominant force.

An interesting outcome of the design process in the individual HyperCard® projects was the failure of students to apply any of the standardising principles of interface design discussed in earlier classes. These were the principles they had found no difficulty in identifying in the work of others, but paid very little attention to in their own work. These were more a reflection of student character.

### *Opinions*

In the individual responses to the questionnaire (Appendix I) that students completed and mailed back after the course, they expressed their opinions on grouping, evaluation, the application of skills while at university, the application of skills within a school, the long term benefits of the course with no follow-up, and general comments.

Nine questionnaires were returned of the fourteen distributed. A summary of the range of student opinions follows. Full responses from each student can be browsed in *The Garden (Figure 5.1—E*).

*Grouping* : Some positive responses were noted for all grouping arrangements:

> *"I thought it worked out well. We were able to use our own motivation in combination with others as well as their ideas and input throughout the course, even while doing individual work. That is how real life situations work ideally, and I have found it very effective."*

Group work also received some negative responses:

> *"I found working in the large groups difficult as it meant that certain people dominated while others did very little. The times when we worked singly or in pairs was when I learned more and produced more work."*

*Evaluation* : Mastery was acceptable for skills testing, with the exception of a perceived bias in favour of students in this subject as compared with students studying other subjects in the Bachelor of Teaching/Education course. Expert status was well received:

*"Grading of "expert status" was very good. Grading in the subject began mid session, which gave us the opportunity to gain confidence before being tested. It shouldn't be changed."*

One additional suggestion was the subsequent testing of all students for all digitising skills. Grading was regarded as appropriate for the application of skills:

*"The blend between mastery and grading was very appropriate. Mastery is essential when trying to grasp a new skill such as sound digitising, but when applying these skills grading should be used to give credit to those applying more effort and time."*

*Immediate Application at University* : Students mentioned use of skills acquired in the course for presentations, lessons, units of work, tests and assignment. The following response indicates a practical application for future use:

*"I could see myself using these skills to develop a particular theme. Often the ideal resources are not available in a way that you can use them with a class but the technology introduced throughout the course allows the materials to be transformed into a format that is more appropriate and accessible."*

No students considered the use of these skills for self-regulated learning— they were purely task oriented.

*Application within Schools* : Students mentioned use of these skills in classrooms for both teachers and students:

*"I think these skills could be used very effectively in the classroom (if you ever find a school with this equipment!) for students to design project work and for creative writing publishing. The teacher can also use these skills to design small programs which are specifically suited to the students in their class eg tests, questionnaires, etc."*

The applications for students encompassed student production of stacks, student production of personal profiles and creative writing. Teachers could use the skills for administration, tests, lessons, and as an instructional tool.

*Long term Benefits of the Course* : Students were positive about long term benefits of the course:

*"I think the course would still be value for money as it provided me with the knowledge that computers are not only for 'left brain' dominant people, but are just as effective as a creative tool."*

*"This course has provided us with the basic skills to attempt and perfect new uses for the applications used but also removed inhibitions to tackle new software applications."*

*"Yes, because the skills we have learned have provided us with enough knowledge to create small and effective programs which would be very useful in the classroom."*

*Additional Comments* : Students used this section to personally thank the researcher for teaching efforts, and to comment on features or problems of the course:

*"Thanks for your help Chris, throughout this session."*

*"A good feature of the course was to have the allocated "experts" in each area, as it gave the teachers a bit of a break (when everything was working properly!) and I think we learned a lot more by learning through each other's experiences eg "don't do that because I did it and this happened" etc"*

*"Time constraints were the only problem, but you know about that. There is so much to learn, it is impossible to chop out part of the course— it's all too important (and interesting, fun, etc)"*

### Reflections

From the teacher/researcher/designer perspective, the course was a positive experience. In the constructivist fashion of recursive curriculum design, teacher reflections must then translate into recommendations for subsequent courses:

- If the course structure is maintained, the course should run for fourteen weeks, to enable the group project to reach fruition based on student design.
- The group project could be run with groups of 5-7 students. If students within a group occupied a major and minor role within the list of scanning, video digitising, sound digitising, scripting, graphics, manager and researcher, then the group projects could be self-contained. The dual role of students would avoid group paralysis in the event of absenteeism, and capitalise on the student support for work in pairs.

- Tailoring of performance support tools is crucial to the teacher role of support. facilitation and modeling. Support tools should therefore be developed during the course in response to perceived needs.
- Video digitising should be a skill developed as an extension exercise only by students with a definite interest in this process. Currently, the problems of video digitising outweigh the benefits. Digital video cameras will change this situation in time.
- Negotiation skills should be discussed in the theory strand of the course as an aspect of the group work which accompanies instructional design. This would help students overcome many of the competitive and defensive attitudes to group work.
- Evaluation should be predominantly mastery of skills, grading by staff and peers of an individual project, and grading of individual process notes on the group project. Peers may come from the same and/or another class.

## EDUM 212—Information Technology Development Project

This elective subject was conducted in Semester 2, 1994 with five pre-service primary teachers in the Bachelor of Teaching in Primary Education program. The researcher was fully responsible for the three hour class each week.

This was a specialist elective in interactive multimedia. All students in this elective had completed EDUM 221 in the previous semester.

### 5.1.5 The Process of Group Collaboration

A description of each laboratory session from the teacher/reasercher/designer perspective is listed in Appendix N. Detailed teacher notes and student profiles are available in *The Garden* (*Figure 5.1—G,C*).

With such a small group, there was no set pattern to the classes, which were responsive to individual student, task and project needs. On reflection and analysis, the fundamental class activities which combined in different ways were:

- individual resource production
- "Show and Tell" sessions for completed tasks
- tailored scripting demonstrations
- negotiation of tasks or assessment
- individual oral reports on progress
- video taping of diary reports or class discussion

- self-monitoring and regulation of a major project
- individual scripting support
- group support for ideas
- synchronised tutorial for animation
- exploration of animation
- problem-solving with equipment

Students launched independently into resource production from the first class, confident that if they couldn't work something out, there was plenty of assistance. When students were given free production time in classes, it was rarely that teacher attention was focused on production, except when there were technical difficulties. If these could not be solved, alternate activities were pursued so as not to waste time. Students had to develop a flexible approach to production. By the end of the course, at least nine applications were routinely used for image, sound, video or animation production.

"Show and Tell" sessions remained vital for demonstration and discussion of completed tasks. Apart from the major project, there were two other tasks the students had to complete— an animation, and the outline of a lesson which capitalised on computer use in a unique way. In both instances, there were either other staff members present, or postgraduate students in the lab. As the semester progressed and pressure mounted with project work for postgraduates, it was not unusual for other students or staff to be using spare machines in the lab or development area. This served to provide a real audience, in addition to the formality of the video process. Students received additional support not only from the presence of others but also from their intense interest in proceedings. The EDUM 212 students were regarded as relative "experts" with a range of procedures.

Scripting demonstrations by the teacher were aimed at expanding student awareness of the programming possibilities with HyperCard®. These demonstrations were conducted at different times each class for the first six weeks, except week three. During week one, the following features of HyperCard® were discussed:

- the message hierarchy and trialing the difference between background and card buttons - there isn't any - both pass the message on next to the card.
- different backgrounds in a stack - how common navigation buttons are simply pasted in the background and occupy an identical location.
- where to place scripts so they affect all cards in a background, or all cards in a stack, and how to deal with the exception (by blocking the message to the background or stack)

- the fact that every card holds the information for its background, and you can cut and paste and re-order cards, and they carry their background information with them. So, all cards in the one background don't have to be together.
- the ability to set the enabled/disabled property of a button so it greys out and is not functional.

In week two, scripting issues covered the common technique of showing and hiding different objects, the effect of placing scripts at different object levels in HyperCard®, and the logical flow of script.

Scripting needs in week four were generated from class discussion and note taking on butcher's paper, when we reached the heading "Programming". Students wanted to know how to build a menu and disable items, how to use the Media menu with this background field "Movie Script" (a procedure from the HyperCard® support stack developed by the teacher/designer), and how to automatically generate cards with the name specified by the user. Each of these features was later demonstrated in an empty template stack from the group project in EDUM 221, last semester.

The features demonstrated in week five related to anticipated needs. The example shown for the Showlist function was a class list from which an item could be selected. Scripts to sort and print numerous fields were also considered handy, if a program was to offer the user something to take away with them.

The stimulus for the scripting demonstration in week six came from a student interview, in which one student who would not come and directly ask for help, or accept the offer when made, mentioned trouble establishing multiple menus. The demonstration built to assist that student dealt with multiple menus, how to handle whether a card name was already used, how to read text in to a HyperCard® stack and how to write to disk from HyperCard®. The latter procedures were also aimed at other group members. No further scripting demonstrations occurred throughout the course on a group basis. All subsequent assistance was on an individual basis.

With a group of five students, it was natural to engage in the process of negotiation—on the course outline, the nature of tasks, and assessment criteria for the major project. Since peer assessment of the major project would contribute 20% of the course mark, this collaborative arrangement was very important to initiate and maintain group cohesion. Negotiation meant all students had a chance to voice their opinions, but disapproval alone was not enough to alter any situation if an alternative was not offered. The stimulus to justify suggestions allowed students to hear the reasoning of the teacher— an excellent opportunity to model metacognitive strategies and explore the teacher's perspective.

Students presented individual oral reports on their project ideas (week one), tasks the user would engage in within their program (week two), their resource and programming needs (week four), and the progress of their projects (week five). The presentations in weeks one and five were video recorded. Students were keen to verbalise their ideas, and initially suggested weekly diary entries could be accomplished efficiently as short video clips. The group discussion in week seven was video recorded on student request. Video was seen as a handy tool for reflection. While it saved note-taking at the time of recording, students gave little thought to the subsequent time-consuming process of watching and transcribing the video.

Each student was completely responsible for the resource management of their major project. This required monitoring, organisation and self-regulation. The less structured class time was used to produce, socialise, discuss projects, exchange ideas, seek moral support and share problems. Generally students seemed to remain on task, and for every minute they may have "wasted" in class, there was often a multiple of that time consumed at home or in the multimedia lab outside class time. Not everyone could be at their most productive within class and the equipment did not always oblige the keen student. It would have been difficult for any observer to decide what represented "wasted time"— was it inaction, or laughter and social chat, or time on another task? Any of these may have been relevant from the student's perspective. As a group facilitator, the teacher made no attempt to direct activity when students appeared to be "off task".

Teacher attention was directed towards students who were actively involved or who requested assistance. A considerable amount of that assistance was devoted to scripting support (see *Table 5.2*). Some students were happy to seek direct scripting support. As the interactive functionality of their program increased, this often prompted further requests for related or more complex interactive elements.

Other students were extremely reluctant to request support or to accept the offer of help. The teacher's response was to demonstrate perceived scripting needs in the class scripting demonstration the following week. While that meant some students were sitting watching procedures they may not apply to their current program, it was considered valuable information for all students, as a means of raising awareness of scripting possibilities. The researcher also saw it as a necessary support strategy for students who rejected direct support.

| Week | | Gavin | Glenn | Joaney | Cara | Michael |
|---|---|---|---|---|---|---|
| 1 | # | | (*) | | | |
| 2 | # | | (*) | | * | * |
| 3 | | | | | | * * |
| 4 | # | | (*) | | * | |
| 5 | # | * | (*) | | * | |
| 6 | # | (*) | (*) | | * | * * |
| 7 | | * | | | * | * |
| 8 | | | | | | |
| 9 | | * | | | * | * * |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | | | | | | |
| 13 | | | | * * | * * * | * |
| 14 | | | | * | | |

*Table 5.2 Direct and Indirect Scripting Support for Students*

KEY:

# Scripting Demonstration

* Direct Individual Help

(*) Indirect help via Scripting Demonstration

The shaded areas represent weeks when other activities dominated the class.

Alternate activities dominated class time for four of the fourteen weeks. One such activity was the animation tutorial in week eight. Unlike the tutorials in HyperStudio® and HyperCard® in EDUM 221, this AddMotion animation tutorial was run as a synchronised exercise, due to the small student numbers and sheer waste of paper printing additional tutorial support material. The student handout covered the principles of the program, gave labeled images of the palettes, and discussed menu options. Once students had viewed the stack "Principles of Animation", they were verbally walked through the first two lessons of the AddMotion II tutorial in the AddMotion Manual. At first students seemed disappointed that they were not working in colour, but that soon disappeared as action began on the screen. Following this rather intense sitting, students were then free to create their own animation in colour.

The pattern of response to animation was varied. Only one student expressed negative feelings about animation, equating problems with a lack of creativity. The teacher perception of the class at the end of the tutorial session was a general feeling of cognitive overload tempered by excitement. For all bar one student, this was translated into a challenge. In the following four weeks, students spent a varied time on their animation task. The student who felt he was non-creative was the last to attempt the task, but on demonstration day, was one of the most excited.

The animation task exposed the students to a different form of problem-solving. There was no expectation that animation would be present in the major projects. For most students, the delight of animation was in the trial and error of the creation process. Students also persisted in the face of repeated failure.

Group rapport was very strong, and students were highly supportive of each other with project ideas, and with technical assistance. In the second half of the course, preoccupation with other tasks and last minute resource production or scripting lowered the time students could spend in this feedback role.

One of the real tests of acceptance of the technology was the students' approach to equipment malfunction. One class in particular, in week eleven, tested everyone's patience and resilience, teacher included. The following extract from teacher notes paints the scene— there will always be a class like this one:

> *"what a lesson! Could anything else go wrong! It should be noted that Matthew was not available for technical support today, and that the 10 day workshop led to several significant changes to machines recently...*
>
> *Glenn worked on his documentation for a while, then began playing with his CD (games, sounds, images). He spent little time on task today, but did not have material from the school to digitise, and has already completed his animation. I can't complain he is behind, and was quite happy to leave him be.*
>
> *We tried AddMotion on the PowerMacs and it kept crashing. When you copied then opened the Addmotion stack that was on the server, no icon appeared on the Home stack, which was very suspicious.*
>
> *Joaney scanned some images, then after attempting unsuccessfully to digitise a movie, organised all her work on the one machine (PowerMac near the door). Today Joaney had more time for once, and nothing would work properly for her.*
>
> *Lara tried to work on her animation, but AddMotion kept giving her problems. She persisted repeatedly, but to no real avail. Lara was really hoping to finish her animation today.*

*Michael played with his stack- images would work then disappear. He wanted to do some scripting, but in the manner he asked, he wanted me to do the scripting, and him to watch. I avoided this situation...*

*Gavin tried some digitising, which failed as it had done for the rest of us ( it is an interesting phenomenon that we all had a go, even though others had failed, each time hoping we would find the problem.) " (PhD Diary, October 13, 1994)*

### 5.1.6 Student Thoughts and Ideas

The five students in the second course were individually interviewed on tape about their reflections and thoughts on the first course. This occurred late in August, in weeks five and six of EDUM 212, so enough time had elapsed to overcome the production "high" at the end of the first course. The interview questions are presented in Appendix J. Student comments can be heard in *The Garden* (*Figure 5.1—F*). Student thoughts were compared on memorable moments, skill development, shared work, teacher/learner perspectives, teacher attributes, teaching strategies, evaluation and barriers to implementation.

*Memorable Moments* : Some memories were of single resources— "Gavin's Bad Movie" in the HyperCard® stack of the 60s and the repetitive whistle of Waltzing Matilda in the HyperStudio® stack about Sydney. Other memories were broader— the chance to do an individual project, which tested your own ideas and production work, the range of comments on people's stacks in the "Show and Tell", the diversity of ideas and formats in the student work, and the experience sitting with the group and working through everyone's ideas. The third group of memories were incident based— the power failure first lesson, and the humour watching the mistakes people made, because you knew you would have made them too, had you not gained from their experience.

*Skill Development* : Four of the five students felt video digitising was the hardest skill to develop, since it involved many steps. Each one had to be correct, and you didn't find out whether everything was all right until the end of the lengthy process. Video work was hard for one student because memory was used rather than accurate notes of the process. The fifth student named scripting as the hardest skill, due to the foreign nature of the language and the technical terms used.

*Shared Work* : Peer characteristics which assisted learning fell into two categories— knowledge and interpersonal qualities. Superior knowledge and skills were important. When one partner worked at a level above the other, the less knowledgeable partner could watch and ask questions. The benefits accrued to both partners, as the more knowledgeable person gained from the teaching process. The interpersonal qualities of the helper were just as important. Peers had to be flexible, easily approachable, respectful of your subservient position, willing to take the time out, and open to your ideas. There was no room for a condescending attitude— regarded as the biggest "turnoff".

*Teacher/Learner Perspectives* : The teacher's sharing of reasons behind selection of classroom strategies was not considered intrusive by the students, since they regarded themselves as teachers already, and felt that the teacher perspective was an important one which was highly relevant to their future teaching role.

*Teacher Attributes* : When students were asked to rate some important teacher attributes, they were asked to consider their views from two perspectives— firstly as a learner, rating the importance of these attributes in their teacher, and secondly as the teacher, rating the need for these attributes in themselves.

The two profiles were quite different for all students. As the learner, regarding the attributes of their information technology teacher:

- interpersonal skills were regarded as the most important attribute in an information technology teacher for a range of reasons. The teacher has to be able to come down to the level of the beginner student, they can't make the student feel small, they need to relate to the students as individuals, and if problems arise in print support material, they are the next line of support.
- organisation was rated equal first or second. Good organisation was vital to monitor the students, and since students were expected to be organised, the teacher should at least model such behaviour.
- technical competence was rated well down the scale— in fact it was the least significant attribute for two students. The availability of technical support was one common reason. The chance to learn from knowledgeable students was considered a bonus for both teacher and students.
- software and print support production was not highly valued by all except one student, who rated it equal first, for its initial value.

As the teacher, regarding the importance of these attributes in themselves:

- interpersonal skills were still very important for the student teachers, who felt they would have to know their children to gain their respect and become more approachable, could not make the children feel small, and could not alienate them by being closed to the students' ideas.
- organisation was very important: "I would not feel comfortable without the technical competence and organisation already worked out."
- technical competence was rated highly by all bar one student who suggested he would not worry if the children knew more than him, though he felt the need for technical competence worried a lot of people. In fact it worried all his peers, and represented a complete reversal of the standard of competence they required of their teacher.
- software and print support materials were far more important to the students when they imagined themselves in the teaching role—it was viewed as an indication to children that the teacher had planned ahead and knew what they were doing.

*Teaching Strategies* : Rather than offer new strategies, students responded with support for strategies used in the course, and extended some of these ideas in the process of discussion. Work in pairs was very popular, for the input of ideas, the need to learn to compromise, and the provision of a person to rely on while learning. The expert status strategy received support as a means of saving teacher time and as a means for students to learn by teaching others. "Show and Tell" was great to provide an audience for work, which made you work harder. Group work was a disappointment due to the incomplete nature of the project, which required more time. The group should also have been re-structured into teams with specific roles. One student felt the demonstration sessions were too long, and that students ought to be sitting at machines, and made to go through the same steps, whether they used the material or not.

*Evaluation* : Answers to this question were specific and diverse:

- design— students should be taught the ideas and process of design. They would have to list objectives for their projects, which would be evaluated according to whether they met the specified objectives.
- objectives— to cover curriculum needs, teachers would have to set the objectives of what was to be learned, and children would then design how to go about that.
- presentation— the end product is important, but the presentation of that work should also be included, as you are developing social skills and creativity, which emerge in the discussion of the product.

- process— the emphasis should be more on how students are doing things than what they achieve. Self-reporting was good as an additional component of evaluation, as students could identify their strengths and weaknesses. An individual process mark would complement the group mark.
- skills— base the evaluation on skills rather than product. Also on whether students were actively involved or just in the background. It would be very hard to give a graded mark for a project.

*Barriers to Implementation* : Of the four suggested barriers to implementation, the first two received heavy weighting:

- lack of equipment— this was equated with lack of money, and was perceived as a large but temporary problem. One student recommended a student:machine ratio of 4:1, and suggested that a school could run with a lab of ten machines, with students rotated through the lab for three hours each week (a two hour and one hour block). Grouping for the lab could be across classes and grades.
- lack of technical skills— some teachers think it is too hard using technology, and others think it just won't happen so they ignore it. The equipment can be present but poorly used, as was the case with a school experienced by one student on practical teaching. Other students felt it was not as big an issue as people made out, and in support of this concept was the suggestion that new skills could be introduced as an exploratory exercise for the students. One recommendation was to have two teachers in multimedia classrooms.
- difficulty monitoring student work— teachers would have to know their students well to monitor this kind of work, but this was not seen as any different from the monitoring of other group work.
- issues of evaluation— this shouldn't be a problem if design was taught properly and objectives were clearly established.

Many of the researcher's ideas emerged during the course of these interviews, prompted by comments the students made, or the initial need to relax the students in the presence of the tape recorder. The conversation was also necessary to lead into the topic of classes last semester. The inclusion of researcher ideas was not considered a problem in terms of bias— the students were familiar enough with the researcher that they spoke their minds very clearly.

### 5.1.7 The Individuality of Major Projects

The individuality of projects demonstrates the degree to which students took the freedom to express their own artistic design, structure and content. The five projects were pressed on CD so that the students could purchase the collection. All chose to do so. Memory limitations do not permit the inclusion of these projects in *The Garden*. The following brief summary of each project cannot do justice to the concepts.

*Stack* - "**World Peace Simulator and Scenario Creator**"

Michael built an engine to create scenarios, and included an example relating to Egypt.


This engine provided the choice of five screen design templates, any of which could be adapted by the student. At any point in scenario building, you could create buttons for multiple options, and pursue each one to develop a storyline in accordance with that option. The power of this program lies in the student generation of ideas and support of multiple scenarios. Both promote group discussion and collaboration.

*Stack* - "**Aborigine TV**"

Lara used the TV channel metaphor to present themes within Aboriginal culture.

This stack was designed to supplement the Aboriginal and Torres Strait Islander Educational Policy Program for year 6. It covers various issues and interests of importance to the Aboriginal community and facilitates more complete and honest class coverage of the material. Students are able to select a channel randomly, and are presented with material within a theme. They must view the text and image/video to collect the hidden word. These words are subsequently used to solve a puzzle.

*Stack :* ***"The Sixties"***

Joaney built a walk-through house set in the exciting sixties to link history with life.


As you navigate your way around the house, you can turn on the radio to hear the hits, watch TV snippets of popular shows, read magazines on fashion, and generally experience the decor of a house of that era. The house metaphor permits the constructor to link an enormous amount of material to a familiar context, and provides students with an understanding that history is what happens to all of us in everyday life. The house/home is a highly significant aspect of that life.

*Stack :* ***"Mt Kembla Field Study Centre"***

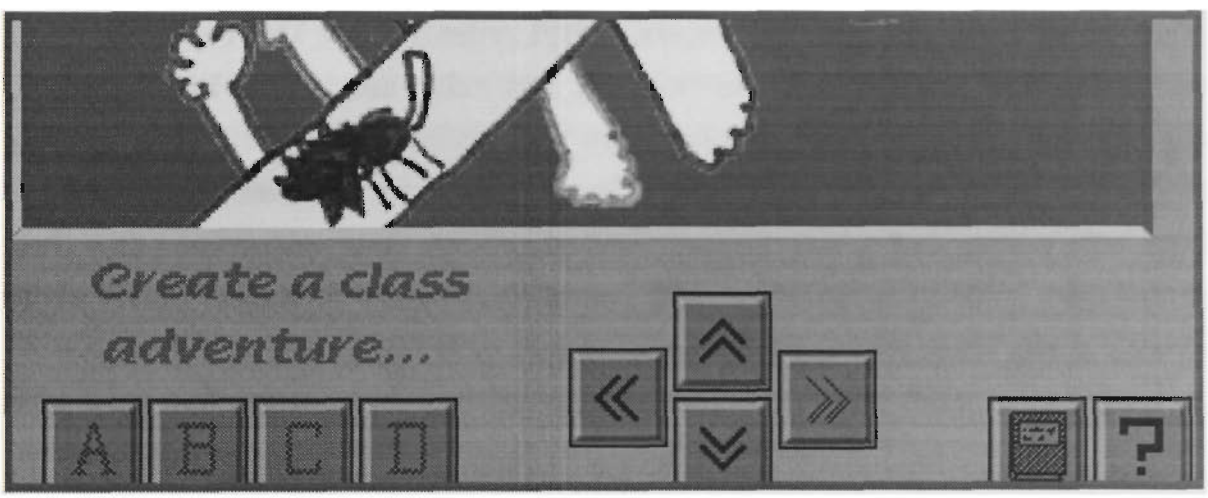
Gavin compiled experiences from a Field Study Centre to promote its valuable work.

The original intention of this stack was that it function as a tool to assist student compilation of information gathered on field trips. When the opportunity arose for Gavin to work with the Mt Kembla Field Study Centre, the function of his program had to change. The needs of the Centre were more along the lines of an information kiosk. They wanted teacher access to material such as reference packs containing information for booking, planning and preparation of excursions.

Gavin was then torn between the information provision needs of the Field Study Centre and his original concept. The resulting stack at presentation reflected this two way tug, and was barely functional, though it was accompanied by numerous video, graphic and anecdotal resources which Gavin had collected after many days accompanying field trips.

*Stack :* ***"The Generic Adventure Stack"***

Glenn created a multimedia construction shell for teachers to incorporate student work.




He worked with a kindergarten/year 1 composite class over a seven week period, assisted by group leaders from years 5 or 6. Children were shown an adventure game, then proceeded to map their own ideas on butchers paper. The story sections were given a grid allocation, then groups worked to produce the media for their grid modules. All digitising and construction occurred in the Multimedia Laboratory in the Faculty of Education at the University of Wollongong, since the K/1 class only had one computer.

These five major projects were demonstrated in a video recorded Show and Tell session in the final class. The presentation component was a significant part of project evaluation. While the nature of the product was important, this did not outweigh the verbal description of the process the students were able to give. In all instances this added another dimension to the project. The reasoning behind certain design decisions was fascinating.

### 5.1.8 Resources and Process Outcomes

#### Resources

*People* : The most significant people in the development of the individual projects were those in the class group— the teacher and students. All provided feedback, shared skills as they developed, and were able to offer ideas from a less emotionally attached viewpoint than the stack creator.

In two projects, other people were highly significant in the provision of resources. In production of *The Generic Adventure Stack*, the children of K/1 class and their year 5-6 group leaders were the generators of stack content. While to some extent they may have been limited by availability of technical equipment such as video cameras, in general the nature of the resources they generated was limited only by the creative imagination of the students.

In *Mt Kembla Field Study Centre*, Field Centre staff were interested in the passive presentation of information rather than the provision of a shell into which field centre visitors could actively incorporate their own media resources and personal reflections. With hindsight and more time, both agendas could have been achieved. The software shell with construction tools could have been used by staff to incorporate what aspects of the Field Centre they wished to share with others. The same software could therefore have served in content-filled state as a presentation device for staff, and in its empty state as a tool for teachers and students to take away with them to construct their personal representations.

*Machines* : The small group of students in this class in comparison with the number of available machines meant students were in no way restricted by lack of a machine, unless their favourite one was in use by someone else. It was common for students to develop an affinity with a particular machine due to its position in the room, or its processor speed, or for some other totally individual reason. After an initial polite expression of annoyance that the preferred worksite was not available (usually with body language), students then settled on another machine. Once this happened a number of times, the repertoire of successful "workhorses" enlarged to the point where students became versatile and no longer worried about the machine in their goal to get the job done. Motivation moved more from an emotional to a task oriented focus.

The inclusion of new machines during the course generated considerable confusion and some students consciously chose to avoid the new machines, claiming they "didn't trust them". In some instances, particularly with animation exercises using the AddMotion stack in HyperCard, their fears were totally justified, as the application quit repeatedly asking for a "floating point co-processor". To alleviate the student generation of angst with the application and the machine, the teacher presented the problem as one of incompatability between machine and application, each highly effective in separate domains. The issue was one of re-defining those domains with changing conditions. Much software was not yet updated to take advantage of PowerPC capabilities.

*Media*: Media requirements varied in accordance with individual project needs. Having taken the diverse nature of topics into account, there were two styles of media use to emerge. The first style was the media-rich information landscape, which relied on the use of visual metaphors to guide the user around an information space rich in images, video snippets and audio support. Although text use was minimal, the user was provided with a notebook facility to allow them to record their thoughts and ideas as they used the program. *Aborigine TV*, *The Sixties*, *Mt Kembla Field Study Centre* and *The Generic Adventure Stack* all followed this pattern.

The second style was the text dominant engine, which relied less on the use of media to capture attention and more on comparison between user generated and program generated text scenarios. Media complemented but did not drive this process. *World Peace Simulator and Scenario Creator* was the only project to pursue this style.

*Teacher Tools*: Print support material was of immediate use in class, for such exercises as the scripting demonstrations. Here students needed reference material they could personally annotate. A teacher cannot predict the time and place such scripting knowledge may be required.

When the execution of more than a few simple steps is demonstrated in a computer application, print support material is vital, even with live demonstration just prior to student practice. Anxiety, mental lethargy or the sheer cognitive load of anticipated content will hamper student memory and lead to omission of important steps. The need for tailored print support material is short lived but vital to avoid immense student frustration. Once a series of steps becomes automatic to the student, they can leave the print support behind. With continued practice, they may establish a different routine which is more efficient for them and in keeping with their own production style. The initial model will still provide them with an alternate strategy for other situations.

Video recording of student project progress reports began as a positive exercise in the first class. The presence of other staff members in the computer laboratory the following week seemed to disrupt the students' ability to focus and discuss their progress on video. They never regained their initial level of enthusiasm for a video diary, although the video camera was used at student request to report on project progress in later weeks. To remain a convenient technique, the video camera would need to be portable and convenient, not tied to a power point and tripod. The formality associated with setting up or moving video equipment is not compatible with the spontaneous capture of a lively and productive group discussion.

The performance support tools designed to demonstrate scripting techniques gave the students a repertoire of possible interactive functionality which they could choose to adopt, adapt or leave alone. These tools were invaluable to the student who had the capacity to cut and paste code and follow the formal logic of a script to identify and deal with bugs. These tools were dangerous in the hands of students who simply took whole slabs of code, identified them with some general functionality, then proceeded to mix and match code at will, without reading through the logic of what the whole piece was doing.

Student ability to systematically problem solve with code one line at a time appears to be a strategy which does not often come naturally. Even when this process was modeled on a number of occasions to a particular student, in fixing a chunk of code which was there, the same principle was rarely applied when they generated their own lines of new code. The rapid generation of unworkable code was a source of enormous student frustration and loss of motivation. When the teacher sat and worked through one strategy at a time to get each aspect working, students often did not understand why all functionality was not immediately generated. The delightful spin-off of this teaching strategy was a number of very creative routines generated on the way to something more complex. These creative routines often solved someone else's problem.

### *Process Outcomes*

Each student, in researching, planning, organising, and synthesising material in an individual project within a specified time period, demonstrated significant development of metacognitive skills. Due to demands on digitising equipment, teacher time for scripting support, and the inevitable setbacks with equipment malfunction for whatever reason, students also had to plan with flexibility in mind and use their time efficiently.

With the drive of an evolving and self-selected project, students pushed resource production skills. They solved digitising problems on a need-to-know basis, driven by the desire to include a particular resource format or style in their project. The group production standard rose with each student discovery of a new technique, such as a special effect in an image editing package like Adobe PhotoShop®.

The inclusion of the animation task, while not an anticipated aspect of the major project, facilitated the development of problem-solving skills associated with multiple variables. Actors and backdrop had to be synchronised, and if sound was also featured, this increased the complexity of the exercise many times. After the experience of animation, straight image, video or sound production was considered a routine exercise.

Students developed better mental models of resource locations than they had exhibited in the previous course. Since they were solely responsible for their project work, it was up to them to manage the placement of their stack and its resources. Students soon learned of the importance of a backup copy. This necessitated some means of version control, to ensure they did not overwrite a later copy with an earlier one. Hence the students were forced to develop their own protocol for version naming, backup and storage, and a good mental model of where everything was.

The big step for students in this process was to become aware that material was located on the server, not on their local machine. Once students adopted the habit of transferring their stacks from the server to their local machine to work on them, their ability to deal with the whereabouts of resources and backup copies improved dramatically.

Student motivation to work on a project of their own choice was high. Topic selection was based on individual interests and perceived application to the classroom. In the two projects where other people became involved—*The Generic Adventure Stack* and *Mt Kembla Field Study Centre*, the students responsible for these projects experienced the influence on the production process of other people who have entirely different agendas.

In the former case, the infants and primary school students were driven by their creativity and the adventure story they were generating, not what was possible or easy to produce with the technology. This can place quite a demand on the person who is responsible for keeping production within tight technical and time limits.

In the latter case, the staff at the Field Study Centre were driven by a need to promote their work. They lacked an awareness of the more active orientation of the student and alternate capabilities of interactive multimedia.

Students developed collaborative skills. They shared experiences, strategies and production skills in our weekly classes, and were supportive of the emotional needs of others. Despite all this sharing, the class experience generated a group of individuals whose interactive multimedia capabilities were diverse. The following teacher observations were shared with the students just prior to the final "Show and Tell" session.

*Glenn* began the course with sound scripting ability. Through the selection of his project topic, he balanced scripting and production skills with an empathy for the children's needs in the classroom. Glenn reached a better understanding that his scripting abilities could be put to great use if he listened carefully to the needs of the students.

*Lara* demonstrated an ability to keep tabs on fine detail, and do the worrying for everybody else. Her experience with the G&T class showed, as she often oscillated between the roles of teacher and student within this class. It was Lara who worried and said something if she felt other students appeared to be "off task". At the same time it was occasionally Lara who felt frustrated with her project and spent some of her class time on e-mail or completing a presentation assignment for another class.

*Joaney* showed an abundance of creative ideas and an appreciation of how to use the full range of audiovisual facilities. Her ability to gear her programs to the primary school level was apparent very quickly. Joaney demonstrated the interactive multimedia equivalent of an author of children's books— a marvelous affinity with the imagination of a young target audience.

*Gavin* had marvelous creative flare with graphics, which was unfortunately coupled with a tendency to ditch what he regarded as substandard material. His perfectionist standards meant that Gavin often trashed material most of us would have been happy to work with, and in the process he left himself with no replacement. Gavin needed other team members to manage his material, and help with scripting, but he would certainly help bring out the best screen design in any group.

*Michael* persisted in the face of hardship, and pushed program ideas beyond his scripting ability when he saw functionality which could be applied to his project. He showed no understanding of the word "can't", and was always prepared to ask for help to advance the structure and functionality of his program. He generated a significant amount of content in his scenario example, demonstrating a joy in the creation of unique material. Due to colour blindness, Michael was not overly concerned about "superficial features" like screen design.

In the abundance of group discussion each class, there was a surprising absence of reference to any theory relating to instructional design. This was theory which had been covered in the lecture segment in the early weeks of EDUM 221. Students rarely asked for advice on interface, did not rely on design statements for organisation and direction, and seemed more interested in presenting their unique production than a production geared to an established set of criteria.

The singular word to capture use of time in this class was flexibility. Student attendance was flexible, and classes were planned with that in mind. Appointments between students and the teacher were arranged outside class time, but frequently assistance from the teacher between classes occurred spontaneously when a student visited the laboratory.

The three hour sessions each week were certainly extended well beyond this time allocation. The class often began unofficially before 1.30 pm, and repeatedly extended beyond 4.30 pm. The Interactive Multimedia Laboratory was available to students most days within normal undergraduate class hours (8.30 am to 4.30 pm) so student access to production facilities was abundant.

Students developed a positive attitude to information technology and demonstrated an ability to deal with technical problems. They began to regard technical problems as a problem-solving challenge. They had experienced enough success and diversity of approaches to realise that there were often numerous ways to achieve a similar outcome. Each student in this class experienced a short period of casual employment in the field of information technology during the holiday break after the class. One student has since been employed on a full-time commercial basis to develop interactive multimedia materials.

## 5.2 Class G&T— Gifted and Talented Primary Students

Twenty two gifted and talented students in years five or six from nine local primary schools met one day each week— Thursday, for an extension class, under the guidance of a teacher who worked exclusively with this class. One hour each Thursday was officially timetabled for computer work.

The researcher was responsible for developing and supporting the activities which occupied this hour. A student from the EDUM class was a voluntary assistant for 21 of the 27 classes. The class teacher was present for the computer hour, so the standard teaching team was researcher, class teacher and voluntary assistant.

The full data set for the Gifted and Talented class can be found on the CD as indicated in *Figure 5.2* on the following page.

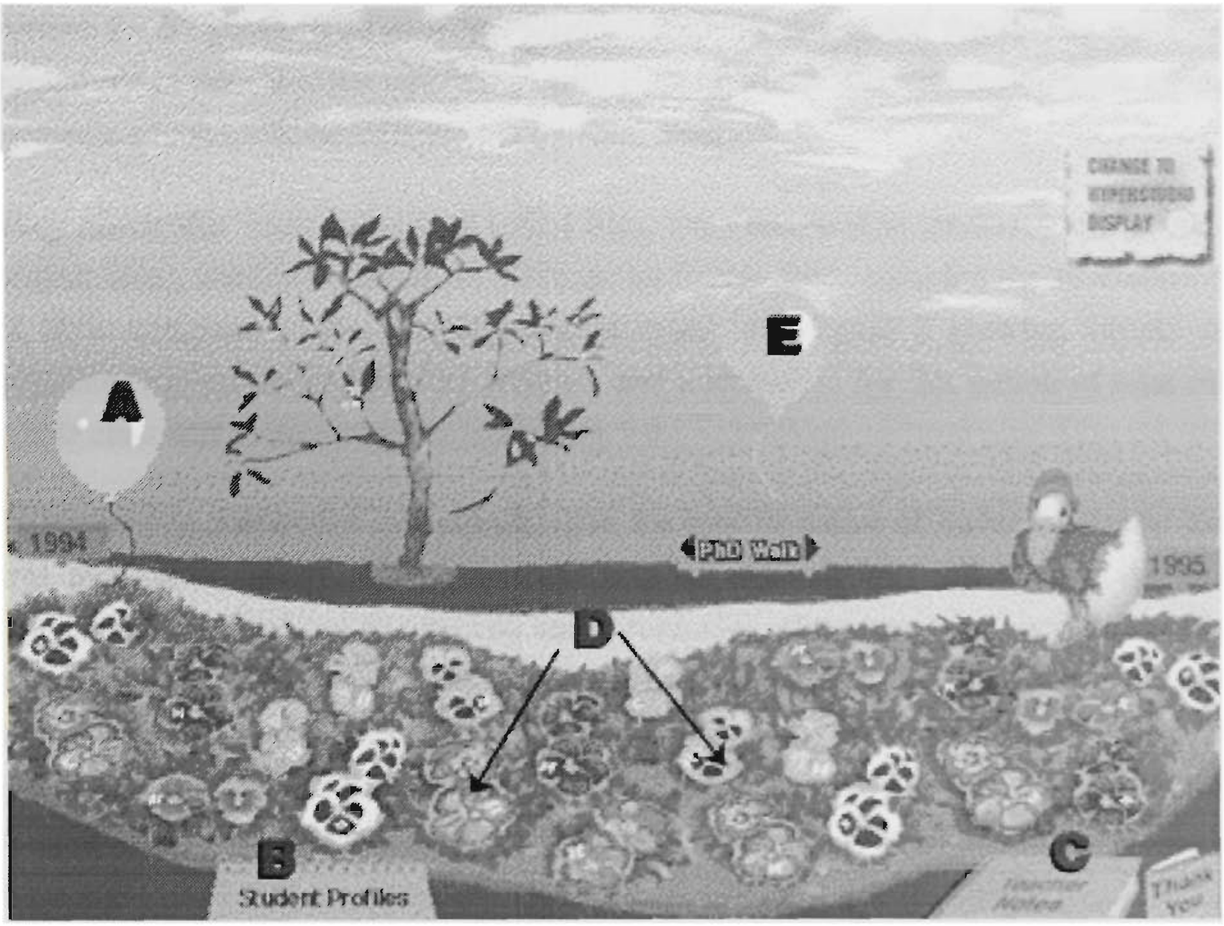



*Figure 5.2 : G&T Map Showing Class Data*

KEY A - Student Thoughts B - Student Profiles C - Teacher Notes
D - Student Projects E - Class Teacher's Opinions

### 5.2.1 Class Process

Overall, class activities varied in a series of waves, dictated by such factors as student familiarity with the technology, availability of equipment, access time to the computer laboratory, other dominant class activities, presence of support staff and the stage of student production work. The following summary of weekly events captures the process of media production and computer mediated construction. Detailed student profiles and teacher notes are available in *The Garden* (*Figure 5.2—B,C*).

*Week 1 : Introductions and Photos* In the first week of class, students were photographed and interviewed in pairs about their background knowledge of computers and potential computer use in school. Students were not familiar with the type of production work they were about to experience using HyperStudio®. Their general comments about computer use can be accessed on the CD (see *Figure 5.2 - A*).

*Weeks 2 - 8 : Basic Skills in HyperStudio®* Students developed familiarity with the equipment in the computer laboratory, with HyperStudio® and with the multiple media elements which could be orchestrated by HyperStudio®.

They added text items, generated sound files, were recorded in movies, brainstormed project ideas, learned to handle data storage on floppy disks, recorded the development of their computer skills, developed animations and shared a growing supply of computer equipment mostly with patience and tolerance— for this period of time the whole class was in the computer laboratory.

To ensure fair distribution of computer time, the specific nature of student computer use was monitored closely. The researcher recorded class actions following class, and through the processes of file backup and compilation of student work, was constantly aware of student resource production. Researcher generated compilations of student work were shown to students at the beginning of each class up to week six, then specific groups of students were directed to particular activities which they had not accomplished. All students by week eight had generated at least one HyperStudio® stack with a text item, an illustration, a sound file and some graphics work.

In week seven, half the group worked on the old Apple IIe machines which occupied the other half of the computer laboratory. They composed articles for the class Newsletter. Special requests by the classroom teacher for computer use for word processing (such as the Newsletter or Science Reports) took priority over project work. This week was very busy in the computer laboratory, with old and newer machines in use. Amidst this productive atmosphere, a new technique emerged:

> *"The unfolding of animation was in response to student request, and is the first real example of problem-based learning and facilitation when requested. It was wonderful to see how the boys adapted to the concept. Having made the first animation, they realised when they wanted to add flame to the comet that it meant doing the whole thing again! It will be worthwhile showing animation at the beginning of next lesson." (Researcher notes June 2, 1994)*

The *Reflections* stack was demonstrated at the beginning of class in week eight. The following extract from researcher diary notes captures the rationale for display of student work in this manner:

> *"Everyone was glued to the screen - they really like to see each other's work and it is a great way to spread their ideas, not what we think they should be doing." (Researcher notes, June 9, 1994)*

Animation was the rage after the students saw what others were doing. The computer laboratory reached its full complement of computers this week and a small group of students experienced the first video production work.

*Week 9 : Formation of Groups for Projects* The advent of the next production phase. Now more familiar with HyperStudio® and the computer laboratory, the students were organised into groups based on their nominated interest areas. The topics and group arrangements to emerge were:

- Pollution (group of four– one female and three males)
- Minerals (group of four - four males)
- Space (group of four - four males)
- Animals (group of four - four females)
- Horses (group of three - three females)
- Sport (group of two - one male and one female)
- Deafness (one female)

The first three groups went to the computer laboratory and individually worked with the researcher on a brainstorming exercise using *Themes*, the HyperCard® tool produced by the researcher and based on the interrogatives (who, what, why, where, when, how), or explored ideas for their project in HyperStudio®.

Meanwhile, the other four groups went to the school library with their class teacher to begin locating resources for their project. Following school recess, the groups swapped over. Those brainstorming project ideas after exposure to library resources seemed to find the exercise more productive. Students rapidly began to accumulate project resources via submission of numerous library books with images noted for scanning.

*Weeks 10 - 12 : Group Project Production* Students worked in HyperStudio® on their project themes. The full pattern of group production is indicated in *Table 5.3*. In week ten, groups received printouts of their ideas from *Themes* and lists of scanned images. There was not time to load digital versions of those images on the specific machines allocated to each group.

From week eleven, half the groups attended the computer laboratory, while the other half worked on audiovisual production. By week twelve, the computer laboratory was stabilised in its arrangement of machines following the arrival of larger desks. Each group could now use two adjacent computers, so the students had the opportunity to work in pairs or even individually if they wished.

| Week | Animals | Horses | Space | Minerals | Pollution | Sport | Deafness |
|---|---|---|---|---|---|---|---|
| 10 | * | * | * | * | * | * | video |
| 11 | * | * | * | video | sound | WP | WP |
| 12 | video | planning | sound | * | * | * | - |
| 13 | WP | WP | WP | sound | video | planning | video |
| 14 | video | planning | planning | WP | WP | WP | WP |
| 15 | | | | COMPUTER NEWSDAY | | | |
| 16 | * | * | * | sound | video | video | * |
| 17 | Science | Science | Science | * | * | * | * |
| 18 | * | * | * | Science | Science | Science | Science |
| 19 | * | * | * | * | * | * | * |
| 20 | * | * | ES | ES | * | ES | ES |
| 21 | ES | ES | * | * | ES | * | * |
| 22 | * | * | ES | ES | * | ES | ES |
| 23 | ES | ES | * | * | ES | * | - |
| 24 | * | * | Class | Class | * | Class | * |
| 25 (day) | * | Class | * | * | Class | * | Class |
| 26 (day) | * | * | * | Class | * | Class | Class |

*Table 5.3 : Pattern of Group Project Production*

KEY:

| Group Project | Other Class Activities |
|---|---|
| * — Work on Computer | WP — Word Processing |
| Video — Video Production | Science — Science Reports |
| Sound — Sound Production | ES — Endangered Species Project |
| Planning — Project Planning | Class — Other Class Activities |

*Weeks 13 - 15 : Influence of Newsday* Computer Newsday dominated these three weeks. Groups scheduled for the computer laboratory in weeks thirteen and fourteen worked in ClarisWorks® on Newspaper items. Audiovisual production continued as usual for the other groups. At the beginning of week fourteen, the whole class viewed the resources produced so far by the students. This was important to reflect the fruits of audiovisual production. Week fifteen was Newsday - an annual computer event across schools. Students gained skills and experience moving and reformatting files, viewing file retrieval via modem from a bulletin board, working in designated collaborative roles, meeting deadlines, and creating a class newspaper.

*Weeks 16 - 24 : Group Project Production* Students resumed the normal pattern of group project work as if the Newsday had never occurred. They continued alternate weeks of audiovisual production and computer use until week seventeen, when special video production ceased— Science Reports were required and the decision was made to use the limited amount of computer access time left to pull the group resource banks into cohesive projects.

At the beginning of week eighteen, students from the three groups in the computer lab were shown a researcher generated compilation of screens from all group projects, followed by a copy of *Themes* in which they could click through lists of their available images and see what movies and sounds they already had in their group resources. Students were able to identify the images they needed, mark the names on an identical printed list, then return to their own group machine to add the image to their stack. This allowed them to focus on the task at hand and plan new developments in their stack away from the production machine.

The only other way they could view the images they had collected was via HyperStudio® as they generated their stack. This process was slow and somewhat frustrating— the Animals group had 66 images, the Space group had 22 images and the Horses group had 40 images. A mechanism such as *Themes* for rapid browsing of these resources was necessary to use available time efficiently.

Week nineteen was unusual due to massive absenteeism, so all fourteen students present worked in the computer laboratory. For some students who were the only ones present in their group, this gave them an opportunity to create with HyperStudio® unhindered. One member of the Pollution group generated a ten card animation just sitting working quietly.

Weeks twenty to twenty four were productive for all groups. The following snippets from the researcher notes capture the diversity of production approaches. Susan and Matthew liked to adopt a systematic approach to stack construction:

> *"They asked about the text item, then the image addition, and I left them to type in the content. They have put a lot of information on that screen. This pair have a great sense of the sequence of what they are doing, and like to walk you through the stack." (Researcher notes September 22, 1994)*

Although HyperStudio® was easy to use, students often asked how to perform simple operations when they were immersed in content. They did not seem at all concerned about mastery of skills in HyperStudio®.

Solitary work was often popular:

*"Keryn worked on quietly as is her way. She was trying to make a screen with a hand drawn title "Graphics", and was not pleased with the results! As Ben worked things out next to her, she kept an eye on his progress and learnt from his mistakes.*

*... Brendon worked by himself...For once Brendon was completely absorbed in what he was doing, and didn't even notice the noise around!" (Researcher notes, October 13, 1994)*

The computer laboratory was often noisy, for a host of reasons:

*"Chloe burst into poetry! I told her she should create a text item and begin typing in the poem while she remembered it! Chloe did just that!*

*... Every now and then through the lesson you would hear a "YES!" from Ann, as she completed another card or feature. Ann achieved in today's lesson what others take weeks to add.*

*... Laura was working on her stack for a while, when I heard a giggle. She has a wonderful ability with cartoon style graphics, and had drawn a bird on the screen, with the caption about an unusual bird. She then posed a question to the user about whether they wanted to shoot or look after the bird. These options were accompanied by buttons. If you chose to shoot the bird, Laura had drawn a bird in the sky with blood and a wound. ... Daniel became involved in Laura's production, and claims his input is the blood on the bird! Laura's excitement was obvious and infectious." (Researcher notes, October 20, 1994)*

Team work was also necessary:

*"Kyra and Natalie wanted to make a collage of images on one screen. To do this, they needed to make the images smaller. I showed them how...Initially they had some trouble with these keys, but worked as a team, one holding down the keys, the other concentrating on dragging the image to the desired size and place. This pair have worked together extremely well. While they may lose the odd week's production learning and perfecting a new technique, they more than compensate when they next come to class."*

*... The beam on Andrew's face couldn't have been wider. He didn't need to say anything. Susan was really excited, and started to ask if they could put Andrew's atomic bomb animation with a card showing their peace protest. This Pollution*

*group is really starting to pull all their separate ideas together. This is working well, as all the information was planned out in the first place." (Researcher notes, October 20, 1994)*

*Weeks 25 - 26 : Group Projects Finalised* Before the class in week twenty five, the researcher compiled the work of each group into a single group project stack, copying cards of small offshoot stacks and pasting them into the main stack. No specific sequence was applied to this process. The intention of the researcher was not to interfere with student creativity, but merely to enable the groups to see the full collection of cards they had created. The focus of remaining class time was on screen integration, rather than tedious stack compilation on slow machines.

The researcher was available all day for these last two classes, so groups were assisted one at a time, using a PowerMac for speed and memory. The large stacks would no longer run on the LC machines with 4 Mb RAM. Class projects as single stacks had exceeded the technical limits of the available equipment.

During week twenty five, the Space group hit full team production mode, the Sport pair saw their work integrated, and launched into animation, and the Minerals group, which had been quite fragmented, finally gelled. The following week was the final production for Animals, Horses and Pollution groups. One student began a flood of sound production:

*"Chloe recorded her sounds, and this attracted great attention. That was it— sound production was on the move! Brynn and Laura wanted to do some sounds, so I suggested that they script voice-overs for the cards with no text, and list the card number for comments, so I could process and attach them later."*

*... Joshua recorded some sounds for the Space group, involving all present in the lab. He then began playing with the effects in SoundEdit, and lost a few sounds. This did not deter him, as he enjoyed re-recording!" (Researcher notes, November 17, 1994)*

The final presentation of group projects in week twenty seven was an anticlimax. This week marked the end of a special class, with all the associated emotions. The students were quite critical of the project work they saw. The fruits of the process which had pushed them through many emotions was now of passing interest to them. There was sorrow expressed that they could not take the work home to continue it. Although a video output of the presentations was produced for parents, few purchased this video at the replacement cost of a tape to see their children's work.

### 5.2.2 Products

The group projects demonstrated in week twenty seven can be accessed in *The Garden* (*Figure 5.2—D*). The diversity of graphic style is refreshing, and not unexpected. considering there was no formal discussion about screen layout, fonts, colours navigation, interactivity or overall stack structure. The students built what they wanted with the material they had collected in the time they had available.

Each project reflects some unique characteristics of its group members:

- Animals — this group wished to share a common theme, but from the beginning they decided to build individual stacks. Their concern for directing the user to the other stacks showed their sense of unity. They offered each other great peer support. Although their stacks shared no common design features apart from the concept of a guide, this did not seem to worry them.
- Deafness — a group of one. This was always an individual interest, based on the experiences of a personal acquaintance. Once Keryn declared her stack complete, she lost all interest in it.
- Horses — the three members of this group exhibited tremendous patience, perseverance and planning. They chose on several occasions to forego audiovisual production to plan their project. The only video of interest to them would have been video of their pet horses. The animation work in this stack was tremendous, and the range of topics on the horse very extensive.
- Minerals — a rather unstable group of four, with a change in membership half way through, this collection of strong-willed students was always going to struggle for unity. Although it came at a late stage, this unity represented wonderful personal growth for certain members who learnt to share. The project presented a struggle between the game concept and information presentation.
- Pollution — this foursome was always a cohesive team with strong leadership. They planned their ideas from the first week, and did not overwhelm the researcher with resources for digitising unless they were sure they were required. The thoughtful presentation of the topic was very emotive and powerful.
- Space — four students with vivid imaginations, an expansive topic, many mental images of functionality beyond their scope, and a sense of fun. The space topic was a predictable one which was attacked with vigour, under the guidance of strong creative leadership.
- Sport — a sporting pair who took considerable time to decide what particular sport they would focus on and whether in fact they could work together at all. This

was an unlikely partnership until the final stages of the project, when their common interests and complementary skills were realised.

### 5.2.3 Patterns of Resource Use

*People* : The pattern of teacher support and adult attendance in the class is shown in *Table 5.4* on the following page. The general trend was one of diminishing adult attendance, which was beneficial for the children. Their first experience in the computer laboratory (week two) was anything but a private occasion. In addition to the researcher, class teacher and voluntary assistant, there were six other adults present. The extra attendees were from Koonawarra School, the Department of School Education, a local newspaper, and the University of Wollongong. Students could hardly move for adults, yet they did not seem to notice the fuss, only the lack of space.

As classes progressed, the opportunity arose to get to know students individually, as the interest other adults had in the class waned. By week four only the researcher, class teacher and voluntary assistant were there to focus on the students' needs:

> *"We need a few weeks like this without outside interruptions to build the rapport necessary for group work." (Researcher notes, May 12, 1994)*

In the first eight weeks when all students occupied the computer laboratory for the hour from 10 am to 11 am, it was helpful for students learning how to use both computers and HyperStudio® to have the assistance of the researcher and voluntary assistant. The class teacher worked with those students not engaged on the computers. She found this an opportunity to get to know the students as a collaborator, rather than a teacher. The videographer was usually present to record his profile of interesting class snippets. His presence was taken for granted by the students.

Once groups were formed in week nine, and audiovisual production began, the class support team was comprised of the researcher, working with three groups of students on HyperStudio® in the computer laboratory, and the audiovisual/planning team:

- the voluntary assistant, working primarily with audio production
- the videographer, working with the group doing video production, on site
- the classroom teacher, working with the group planning and researching

The videographer was present until week seventeen, when video production work was halted. All groups who chose to produce their own video clips had done so. Audio production was as simple and portable as the tape recorder or computer, so audio work was not halted at any stage.

*Table 5.4: Pattern of Teacher and Visitor Attendance in the Gifted Class*

| Adults Present | Week | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Researcher | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Class Teacher | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Volountary Ass'nt | # | # | # | # | # | # | # | # | # | # | # | # | # | # | # | # | # | # | # | # | # | # | | | | | # |
| Videographer | # | # | # | | # | # | # | # | # | | # | # | # | # | # | # | # | | | | | | | | | | |
| Computer Teacher | | | | | V | V | | V | | | | | | | | | | | | | | | | | | | |
| Visitors | V | V | V | | V | V | | V | | | | | V | V | V | | | | | | | | | | | | |

KEY

+ Researcher

* Class Teacher

# Audiovisual Production support

V Visitors

Due to work commitments, the voluntary assistant was not able to attend classes beyond week twenty one. Unfortunately she missed the fruits of her early labour. Weeks twenty two to twenty five were productive in the computer laboratory. The atmosphere was informal and spontaneous, the children absorbed in what they were creating. There was no pressure to perform beyond the inner motivation of students, and the external motivation of peer response and approval. Students were nonetheless highly engaged in creative expression in the topics they had selected. They took great delight in observing the work of others, and were very supportive and collaborative, not only with technical issues, but also emotional conflicts:

> *"Brendon and Ben reached some heated moments, and Alicia asked me at one time to help them out." (Researcher notes, September 1, 1994)*

*Machines* : The pattern of equipment use with the class is shown in *Table 5.5* on the following page. The original machines with 40 Mb hard drives provided little storage space for HyperStudio® production, so storage of student work was transferred to high density floppy disks. While this taught the students some file management skills, it was frustratingly slow at times, and the disks were an unreliable storage medium. Students rapidly filled a disk, so instead of using the second disk to back up their work, they used it for more work. At the end of every class, the researcher backed up all student work onto an external hard drive to ensure none of the student work was lost. This also provided the researcher with the ability to closely monitor what each student had achieved in a class.

As new machines arrived (week seven), it was possible to consider larger group projects, since these new machines had 80 Mb hard drives, and the computer teacher who ran the laboratory was generous in her allocation of disk space for project work. Machines could be marked for the collection and compilation of resources for a particular project.

It was still necessary with the number of groups to use the 240 Mb external hard drive for one project. The 540 Mb external drive held a copy of all project resources, and mirrored much of what was also on the 240 Mb drive. With two copies of student work, if one was damaged or inadvertently destroyed by a student, there was another copy available. Until these two drives were operational, the researcher was reluctant to allow students to use material on either drive. The drives were not used exclusively for class material, so there was an element of researcher concern whenever students sat down to use a drive that they identified their material with the researcher.

*Table 5.5: Pattern of Equipment Use in the Gifted Class*

| Equipment | Week 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mel 4/40 | | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * | * | | | |
| Terry' s Machine 4/80 | | * | * | * | * | * | * | * | | | | | | | | | | | | | | | | | | | |
| Jake 4/40 | | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * | * | | | |
| Koorie 4/40 | | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * | * | | | |
| Lorrie 4/80 | | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * | * | | | |
| Parent Machine 4/80 | | * | * | * | * | * | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * | * | | | |
| Richie 8/80 | | | | | | | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * | * | * | * | |
| Uno 4/80 | | | | | | | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * | * | * | * | |
| Tina 4/80 | | | | | | | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * | * | * | * | |
| Oscar 4/80 | | | | | | | * | * | * | * | * | * | * | * | | * | * | * | * | * | * | * | * | * | * | * | |
| PowerMac 6100 | | | | | | | | | | | | | | | | | | | | | | | | | | * | |
| PowerMac 7100 AV | | | | | | | | | | | | | | | | | | | | | | | | | * | | * |
| Floppy Disks (HD) | | | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 10 | | 10 | 10 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | |
| 540 Mb Drive | | | | | + | + | + | + | + | + | + | + | + | + | | + | + | + | + | + | + | + | + | + | + | + | |
| 240 Mb Drive | | | | | | | | | | | | + | | | | + | + | + | + | + | + | + | + | + | + | + | + |
| Cartridge Drive | | | | | | | | | | | + | | | | | | | | | | | | | | | | |
| Ion Camera | | | | | | ^ | ^ | ^ | | | | | | | | | | | | | | | | | | | |
| Video Camera | | | | | | | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ | ^ |
| Tape Recorder | ^ | | | | | | | | | | ^ | | ^ | ^ | | ^ | ^ | | ^ | ^ | ^ | | | | | | |
| Colour Projector | | | | | | | | | | | | | | | | | | | | | | | | | | | ^ |

KEY * Computers + Storage Devices ^ Audiovisual Equipment

The use of high density floppy disks diminished considerably once group projects began. Students merely used them to move files from one machine to another, or back up the main project stack until it became too large to fit on a disk. The 540 Mb drive was the one which students used to view resources through *Themes*, the HyperCard® stack which listed images and movies for each project group.

By week twenty five, only one machine in the computer laboratory had enough memory (8Mb RAM) to run most of the group projects. The PowerMacs were required, due to their extra RAM and faster speed. Students loved the rate of production work on these machines. As fast as they discussed changes they were made.

In the specific audiovisual production weeks, most audio production occurred using the tape recorder. This portable, battery powered device was very popular with the students, and brought out some wonderful humour. In the last weeks of production, pushed by lack of time, students used SoundEdit Pro® on the computers as their recording program. These sound files were converted to movies to save memory so HyperStudio® would be able to play sounds and animation at the same time.

The video camera was used exclusively for video production up to week sixteen. It was brought to the computer laboratory and set up every week after that, but was not always used. Lighting in the computer laboratory was not conducive to video recording, so the researcher often just ran the camera to pan around the room and establish who was where, to assist note taking later. The students loved to "drive the camera". Often it was just left in one position and recorded the actions of a particular individual or pair of students for lengthy periods of time.

*Media* : The availability of high quality scanned images on the computer was popular with the students. Some groups requested the scanning of any image which may possibly relate to their project title, while others planned their projects very carefully, submitting material for scanning only when they were sure they would need it. The topics of certain groups, such as Animals, Horses, Sport and Minerals, lent themselves to the rapid accumulation of image banks. With other topics— Pollution, Space and Deafness, the researcher was asked to scan much fewer images.

Through the use of *Themes*, the citation of each image source was conveniently accessed. The researcher was concerned about modeling appropriate strategies for project work even though the focus in this class was not on the development of a polished product, but on the facilitation of learning through the production and construction process.

While many images were scanned, when students sat to select images for their projects, they were very particular in this selection process. Many images never made their way into group projects. Those which were included were often accompanied by emotive or informative text, or interesting voice-overs.

The sound quality of the tape recorder was not high. When students chose to digitise sound directly in the computer, there was usually a lot of background noise. Though it would have been simple to ask those around to be quiet for just a few moments, this request was not commonly made. Students just recorded and ignored what was going on around them. There were some memorable collaborative moments, especially the Space group countdown for rocket launch. The other impressive audio achievement was the number of voices and characters some students could create when recording voice-overs for a whole range of cards. This was achieved in one recording session, without the simultaneous presence of the screens to prompt mood. This meant the students were able to imagine all the screens as they produced a considerable range of voices and intonations. Through audio recording, usually shy students were able to express very creative characters.

The impact of video as a medium was greatest when it placed the students in the active mode of creative dramatic expression. This was supported largely by the presence of a well stocked props room adjacent to the classroom. As *Table 5.3* indicated, the facility was not used indiscriminately. Two groups chose not to include this medium in their projects— they used animation instead. The screen quality of digitised video at a screen depth of 256 colours was a poor substitute for the TV quality of students' expectations.

*Teacher Tools* : Video was not prominent as a teacher tool, as it was in use for production and monitoring purposes.

Print support material provided a framework around which to organise student activity away from the computers. The student skills checklist and individual student folders were eventually replaced by group folders, resource lists and project planning documents. This print record fostered an awareness that resource materials could be difficult to keep track of without systematic organisation, and also permitted students to pick up where they left discussion the previous session. Brainstorming exercises with the alphabet (Appendix E) and the interrogatives (Appendix F) in week 4 allowed students to discuss possible project topics well ahead of the time they would need to make a decision.

The range of software tools developed in HyperStudio® and HyperCard® served both immediate and long term needs. HyperStudio® stacks were used for immediate needs to:

- demonstrate functionality while incorporating aspects of student work for display
- reflect samples of student work back on the class to promote strategy sharing and respect for diverse approaches. During these times, certain stereotypes were broken, as students discovered different production talents.
- link student work for the final display

The simplicity of HyperStudio® as a construction tool permitted the researcher to design these stacks on a needs basis from week to week. They were an effective mechanism to monitor student progress and raise awareness of emerging student talents to be fostered.

The HyperCard® stack *Themes* was a tool developed by the researcher throughout 1992 and 1993 to experiment with a non-linear, thematic form of personal information storage based on user-generated questions. The aim of this tool was to provide the user with the facility to ask questions, then attach their own answers to the associated card or card series. The interrogatives provided not only the brainstorming triggers to help the user generate questions, but also the navigation within the stack.

A theme such as "Horses" may include an endless list of questions— where did horses originate, what are their special dietary requirements, who first made the saddle as we know it, how do you care for foals? Upon re-accessing the theme, the full range of questions could be quickly skimmed by selecting in turn each of the interrogative buttons, which showed the screen of associated questions, or by choosing the menu option to "Select Viewer Pathway", which simultaneously showed all questions in a series of scrolling fields.

Within *Themes*, the user could create pathways through cards within or across themes, in order to give a presentation or simply store a thought trail. They could annotate a card according to the particular pathway, hence the same card could be re-purposed many times through the addition of a tailored comment, according to the purpose of the pathway and its intended audience. This simplified the updating of information, and allowed the user to test the impact of the update on all associated pathways.

This was one of the researcher's conceptions of a personal information web, in which the meaning of any card lay in both the question which spawned it and the many possible links with other cards. The body of knowledge contained in the web could be viewed from many starting points to pursue a multitude of perspectives.

While the scripting for full stack functionality was never completed by the researcher. the basic level of the program provided a brainstorming device for group project discussions in week nine, and a convenient framework to monitor and organise digital resources for the group projects in subsequent weeks. It functioned as a performance support tool, and was re-accessed over a period of time. Students did not have to rely on the print list of scanned images to plan their screens— they could sit and view all digitised images in *Themes*, mark those they wished to use on their list, and plan and record comments about other images for possible future use.

The HyperStudio® stacks produced by the researcher were typical of "disposable software" a teacher may generate and tailor to the unique needs of his/her class. In contrast, *Themes* represented an example of a cognitive tool which could be used repeatedly in a range of situations as determined by the user. The essence of a good tool resides in the user. It is not an inherent quality of the tool itself. "Good" tools can be used poorly if their potential is not understood, while more limited tools can be used very well in the hands of a creative mind.

The software tools were not aimed directly at student learning. They were aimed at support of a process, and were of assistance to the researcher in the construction of an environment conducive to student learning. Their additional roles as multimedia examples and focal points for discussion were valuable in assisting students to begin developing a concept of multimedia literacy.

### *5.2.4 Opinions, Process Outcomes and Reflections*

#### *Opinions*

The researcher tape recorded a discussion with the class teacher during the period of time when group production was in full swing— between classes 19 and 20. This was not a formal interview, although the researcher compiled a list of questions prior to the discussion (see Appendix K) to provide an organising framework and avoid the omission of important issues.

Since this was the second consecutive year the teacher had run the one day per week gifted and talented program, it was possible to make some comparisons with the previous year regarding computer mediated activities. The class in the previous year was held in a local high school, and students had access to a full computer laboratory. with a machine per student, whenever they wished. Computer use was restricted to word processing, as the class teacher did not possess high levels of computer skills and was happy to be led by student interest. Having sought advice from computer coordinators, the teacher was told to stay with word processing or invest some money in an educational game of mid high school level to "extend the children".

In contrast, the facilities at Koonawarra Primary School were not as good, computer numbers were much lower, access time to the computer laboratory was much less flexible, but the improvement in terms of the range of student achievements was “astounding”. Through exploratory student-driven use of HyperStudio®, students were highly motivated to pursue a topic of interest over a lengthy period of time in a flexible manner. They developed computer skills as a side benefit of the production and construction process, and showed intense interest in media production via the tape recorder and video camera. The length of immersion in the project developed interpersonal skills of collaboration, and prompted the need for planning, organisation and management. Students were engaged in higher order thinking about the content rather than focused on learning the skills of production.

The computer project became an integral part of the gifted and talented program, and through a team teaching approach, class and project based activities were flexibly interchanged. This meant many activities the teacher had planned were dropped from the program. This was not unique to the computer activity— the teacher maintained this occurred with Science activities, with excursions or with any other guest presenter who was involved in the course. Each person wanted more time with the children.

Class teacher involvement with the students this year was much closer on an individual and small group basis due to the team teaching approach. The teacher had time with students both in the computer laboratory in the early weeks, and later in media production and library research groups. This was not feasible the previous year. Of special benefit to the class teacher was the opportunity to discuss the class in general with the researcher. Teaching isolation had been a feature of the previous year, since the gifted and talented class was run in a high school environment with no peer support for the teacher.

The planning students put into audio production surprised the class teacher and the researcher. The incorporation of the audio snippet in a computer program provided a rich context, way beyond the act of recording a tape for simple playback as a solitary piece of work. Likewise the video production—though the videographer was an "expert" technician with the camera, the students were the content experts who knew where they wanted that video clip and designed it accordingly. The videographer learned to trust the children's judgment with their clips— they knew what they wanted to achieve.

There was no indication by week nineteen that the children were tired of what they were doing. This was a surprise to the class teacher, who had not expected such student fascination with topics like "minerals" or "pollution". The alternation of audiovisual production and computer work was a way to introduce flexibility, promote diverse and creative forms of expression, and allow the students to specialise in media and computer production.

The team teaching approach was satisfying to all involved, due to the amount of mutual support, generation of ideas, and sustained enthusiasm. This was not an exercise to be attempted alone, and its use would require above all else a flexible approach to the design of class activities from week to week. While the class teacher had thoroughly enjoyed the whole exercise, there was no thought of conducting this activity again without the assistance of the researcher.

### Process Outcomes

There were two general clusters of process outcomes to emerge from this open-ended student-centred interactive multimedia experience. The first cluster could be considered directly related to the infusion of information technology. The second cluster identified some of the spin-off effects which impacted on the nature of interpersonal relationships - the "people issues".

*Direct Effects of the use of information technology* : Students were free to express themselves in multiple modes of representation (text, image, video, audio, animation) in multiple media combinations. They were able to explore and immerse themselves in a personally meaningful topic without the pressure of a product-related deadline. At times they chose to focus on one media form such as video production or electronic image generation. In other sessions they experimented with various combinations of media, and came to appreciate the impact of those combinations on the message they were trying to communicate. The group projects were highly individual in their design, which could have been attributed among other things to group influences, class support for diversity, the relative expertise of individuals, and the specific nature of the topic.

Media selection options were broad, and students availed themselves of the "scanning service" offered by the researcher. This was a great impetus for students to hone their research skills, and they utilised library time very effectively. There was great pleasure derived from the on-screen quality of images. These often stimulated new ideas about presentation. Sometimes images were annotated with text or audio. At other times they were a springboard into student use of the graphics tools within HyperStudio®. Over time, students established their own preferences for graphic style.

Students realised the relationship between media and message. In the first few weeks of basic skills development in HyperStudio® and SoundEdit Pro®, students created their own stacks, entered their story about "cats, exploration and secrets" in a field, recorded themselves reading their story, then attached that audio track to the text screen via a button. The results were quite startling for everyone. Some of the text which was not inspiring to read was captivating when you could hear it read the way the author intended. Students realised the power of audio to convey feelings as a modifier of meaning. Video added the facial expressions and body language to the audio channel. There was a growing awareness of the relationship between media selection and information fidelity.

Knowledge of HyperStudio® functionality was secondary to the content students were focused on. Although HyperStudio® was not difficult to use, students often forgot how to do simple things when they were keen to record an idea or bring in a graphic. This raised the issue of the value of one-off mastery tests for computer skills so common in introductory computer literacy courses. Skills become automated with repetitive use. These students did not have long enough at the computer over a short period of time to develop distinct mental models of how a program like HyperStudio® works. One student who attended the introductory session for parents came along with little enthusiasm for HyperStudio®— what was the point of just clicking buttons? When he was placed in the producer's seat, his attitude was very different. Other students commented at different times that "they had never used a computer like this before." The concept of building your own program was very new to them.

Hardware resources were a limitation on project work over the last few weeks of production. Inadequate RAM was more of a problem than hard disk space. Interestingly, the storage of many Mb of files on the newer 80Mb machines did not disrupt the normal use of the computer laboratory at Koonawarra Primary School. These machines housed the same games and educational software that were loaded on the 40Mb machines, so the additional 40Mb was virtually available for project work. Low levels of RAM and lack of CD-ROM drives prohibited use of most machines for a broader range of software.

The researcher's practice of backing up all student work each week to an external hard drive permitted ample time between classes for reflection, analysis, organisation and planning of the next class. Resource management was an important issue for the teacher (between classes) and students (within classes). Student management of their early files on floppy disks was an experience in personal file management. The subsequent use of floppy disks was mainly for file movement between group project machines. Although the computers were networked for printing, there was no use of the Appletalk® network by students, so all file management and movement was via floppy disks. This placed a limit on portability of student project work once it passed the 1.4Mb threshold of a floppy disk.

Student numbers present in the computer laboratory changed over the period of the study for particular reasons related to optimum group size, the nature and stage of project production work, levels of student absenteeism and requirements of other class tasks. All students were present in the computer laboratory until week 11. By that stage they had acquired basic HyperStudio® skills, selected group project themes, and were beginning project work. It was then appropriate to split the class group according to whether they were involved in audiovisual production or computer construction.

The class split with group project work created an ideal student number in the computer laboratory for construction of group project resources. It permitted project groups to work collaboratively on a number of machines (usually two). The work was not cooperative in the sense that students were still free to explore additional ideas as they evolved. Pre-conceived program structure and delegation of content areas or responsibility were not the dominant forces. Much student work was spontaneous, and it was often initiated by the reflective sessions at the beginning of class. This relaxation of product focus allowed the students to continue to respond to new ideas. They were not locked into previous plans if they chose to explore alternate means of representation.

Students were highly motivated to sustain the exploration of one theme for an extended period of time in a flexible manner. This is analogous to the approach of a researcher, who doggedly pursues a focus of interest in parallel with competing daily challenges and job responsibilities. Long term involvement with a theme permits repeated attempts to identify key issues and analyse material from multiple perspectives. For the students, the breaks in project work such as NewsDay or the need to type up Newsletters or Science Reports were not disruptive to project work. Group folders contained project plans, ideas and resource lists, while the two week breaks between HyperStudio® use allowed students to adopt a fresh approach— they could appraise their work from more of a distance.

*The "People Issues"* : Class activities were driven by the pace and nature of student work, not the wishes of the researcher. After each class, the researcher backed up, recorded and monitored student work, discussed the class with the teaching team, compiled student work, designed a feedback stack to show students the breadth and variety of their work, then planned the next class in conjunction with the class teacher. Arrangements were always flexible in response to changes in attendance, dominance of other class tasks, extended availability of the computer laboratory or limitations of hardware.

Students were placed in the active role as knowledge producers. They had to seek out or generate resources, and compile them in a fashion to suit the needs and wishes of the group. If agreement had to be reached, it was their responsibility to negotiate and settle issues. Those who remained convinced of an idea of their own were often able to persuade the others by virtue of their determination and stamina. Once others could see the idea in action they were happy to accept it.

Group work was a highly flexible concept. In the early weeks of skilling, students were clustered according to resource production areas, and were often teamed up with different students. Once groups were formed for the major projects, flexibility persisted due to fluctuations in attendance and areas of interest. A pair of students working together on an animation one week did not necessarily both work on the same thing the next time computers were available, so the nature or direction of work could change dramatically. Audiovisual production crossed group boundaries. When a crowd was needed for production, students from other groups were more than happy to offer their assistance. When interesting techniques were evolving on one project, such as an extended animation, it was not unusual to find students from another group standing behind the animator quietly observing the action and offering positive feedback.

Focus was placed on the process of production. Students were permitted extended time to explore and indulge an area or technique of interest. They were not rushed according to a production deadline. Animation and student generated graphics required long periods of work, and students were often involved in one screen for several computer sessions. They set their own standards, which were usually very high. Without freedom to determine their own pace, such work could not have been generated.

Many strategies were shared in the reflective sessions at the beginning of computer time. The stacks produced by the researcher provided a focus for discussion, without the embarrassment of students having to put their suggestions forward. When their work appeared on screen, they were then free to answer questions and exchange ideas. The feedback was positive and constructive. Many student talents which may not have otherwise been identified emerged in these sessions.

Peers provided great scaffolding and were an endless source of ideas. Students needed such support with content, skills and creative expression. Sometimes it was easier to fix someone else's problem, due to increased detachment from the outcome. Valuable lessons were learnt by the peer offering support. Not only did they resolve potential problems which may have arisen for them, but they were also prompted to think about the process as they were helping someone else. Peer support was also an opportunity for "time out" from a problem, a break between different tasks or a break from the computer screen.

Team teaching was effective in ensuring that the computer component was an integral part of class activities. Hours allocated to students for project work were flexible from week to week according to availability of the computer laboratory and patterns of other class activities. The team composition was flexible and mutually supportive. Discussions between the researcher and voluntary assistant traveling to and from Koonawarra Primary School, and between the researcher and class teacher via weekly telephone conversations supplied the opportunity for the team to reflect on class happenings and for the researcher and teacher to plan the next class.

### *Reflections*

From the teacher/researcher/designer perspective, the open-ended student-driven experience of interactive multimedia construction with the G&T students was a creative and rewarding experience. Following researcher reflection and analysis, some recommendations are made for classes conducted along similar lines :

- the use of soon-to-be-released portable high capacity (100 Mb) disks instead of 1.4Mb floppy disks would solve the problems of data storage and mobility between machines. They would also permit greater student control over data management.
- teacher tools of print and software variety are valuable in these classes. Print tools provide the organisational framework for students to work independently away from the computers. "Disposable software" should be constructed by the teacher to reflect student ideas. Cognitive tools such as *Themes* provide the students with a software framework to manage their early ideas, test resources and practice media integration.
- production, thinking and organisational strategies can be shared regularly when "disposable software" initiates discussion at the beginning of class sessions. This need not happen each lesson, but certainly should occur when skills, production techniques and concepts reach a new level of sophistication. The potential zone of proximal development is exposed for students to tap into at whatever level they wish.
- student centred exercises should feature prominently as a beginning point, to ensure relevance and context. Once the construction process begins there is

ample opportunity for the teacher and peers to challenge student interpretations and clarify any misunderstandings or ambiguities which arise.

- skill development should occur as a result of student-driven needs. Even initial skill development should involve students in the production of their own resource material. Peer support in skill development provides students with the opportunity to practice their skills, clarify their understanding of the process, and learn more through the conversation involved in the active process of teaching.
- audiovisual production should remain physically separate from computer construction in the early stages of project work, to allow students to focus on the special features of each medium, within the context of planned integration of media.
- process focus is essential within reason. Students should be allowed to explore a technique to exhaustion if they so desire, as long as they are made aware of the consequences of that decision— quality but not quantity. One superb "screen" may be worth more than twenty which are scantily prepared and poorly structured.
- team teaching is important to capitalise on the benefits of student-driven multimedia construction. One person cannot be in more than one place at a time. The team need not comprise purely teachers— it would be highly desirable to incorporate parents and community members of varied ages and interests. This would provide students with a range of opinions, talents and ideas, and a working model of social collaboration and cooperation.
- group work should be featured, but in a flexible manner which is responsive to the needs of individuals at different stages in their development. The group process need not receive specific attention— interpersonal skills are modeled by all class members and teachers. The elimination of the overt competitive factor associated with product development frees students to share ideas without feeling they have given away a "trade secret" which will advantage the "opposition".
- group work should be based on collaboration and cooperation. At times students may want to delegate duties to achieve a goal beyond the scope of the individual. It is important, however, that groups retain the flexibility to alter a planned direction in the light of exciting new development possibilities. The opportunity for collaboration across groups complements the need for cooperation within groups. Removal of overt evaluation pressure facilitates this combination of support strategies.

## 5.3 Emerging Similarities and Differences Across Classes

The classes studies in this chapter—EDUM semesters one (221) and two (212) and G&T have been discussed mainly in terms of resources, processes and process outcomes. The differences span all these aspects. They reflect the contrast in emphasis between skilling students in multimedia production to support evaluation driven product development, and allowing students to use interactive multimedia construction tools to facilitate the processing of content:

- The EDUM 221 students were learning about interactive multimedia production. They had to focus on a range of complex resource production and authoring tools and assimilate some basic principles of instructional design. There was limited time to focus on creative content. Those students who continued with EDUM 212 reached a threshold of comfort with production tools, and were able to develop a major project in which they emphasised content and developed significant awareness of the relationship between knowledge and its structure.
- The G&T students were learning through construction of interactive multimedia using one simple construction tool— HyperStudio®. They focused on content, spent a lot of time resourcing their work (not digitising it), and produced other media extensively— video, sound, scanned images, computer generated graphics, poetry and text. Students were able to indulge their media preferences around an issue of personal interest.

The differences will be explored further in the broader context of interactive multimedia and learning in the following chapter. This chapter will conclude with a discussion of the common aspects of all classes— the processes and process outcomes shared by all students, due to their active involvement with interactive multimedia as knowledge and product designers.

### Common Processes and Process Outcomes

All students displayed high levels of motivation and task engagement. They were free to generate their own resources, although this required additional skills if students were responsible for the digitising process. Through discovery, discussion and reflection, students developed an appreciation for the relationship between media format and message fidelity.

High quality graphics were a universal source of excitement, especially when they were scanned from photographic images of class members. Students delighted in the chance to incorporate personally meaningful graphics in their own program and to explore colour, space and layout in the domain of visual representation. When sounds accompanied images, creative freedom was expressed via humour and emotion.

Skill development with production and construction tools occurred on an individual, paired and collaborative basis. This permitted students to seek moral and technical support when they needed it, and to focus on what they were good at first. There were plenty of peers who could "drag them along" in their proficiency with other skills. Group collaboration was initially strong, as skills were new to all. This changed over time as different individuals developed their own unique profile of expertise.

High task engagement was accompanied by extended periods of involvement. The G&T students could never get enough time in the computer laboratory— they usually had to be dragged out at the end of their mid-morning recess break. EDUM students were often in the multimedia laboratory between class times. It became a place where they enjoyed "hanging out" and developing further production skills.

Creative freedom was expressed via media selection and individuality of interface design. Students were often immersed in the production of one screen (card), to the exclusion of any consideration of other related screens. They did not automatically standardise the placement or colour of screen elements, and even when principles of interface design were discussed, very little standardisation of screen elements occurred. Cultural freedom was evident as students chose their own topics and expressed personal attitudes and values. Screen design was highly emotive and individual. Colour blindness was incapacitating for certain students. This raised awareness of the need to dual code information— colour alone was not enough to indicate differences.

Although all students were engaged in similar tasks, individual differences were increased due to the broad range of skills required for multimedia production and construction. Hidden talents were discovered in the more student-driven environments. Within the first semester EDUM course (221), different students excelled at graphics, interviews, video recording, planning, conceptualising and scripting. As production skills developed further with individual projects in the second semester EDUM course (212), student diversity increased to include skills in field work, research and classroom application of computers. In the G&T class, some students were great organisers and managers, others could execute a plan, many were spontaneous and others were content to just fit in where they were needed. There were orators, artists, poets, writers, actors, animators and directors. Each class provided students with the opportunity to explore untapped talents.

Plagiarism was not an issue. While students expressed enjoyment at the ability to use a graphic which they could not have produced themselves, it was not presented as their own work. These graphics inspired further production resulting in a unique orchestration of media. Students wanted to "add their own flavour". and often did so with sound, captions, or video clips, frequently peppered with humour. Students seemed to find the ability to juxtapose elements fascinating. The concept of originality related more to overall style than content in the sense of factual material. Presentations at Show and Tell had a theatrical feel.

The quality of student work was driven by student standards, which were high. Since media could be edited and transformed so easily, students availed themselves of the editing facilities. The creative tension in the G&T class was high. These students were comfortable with the technology through the use of computer games, and often had high expectations of what they wanted to achieve. Initially this had a negative impact on group project work in some groups— students thought they would be able to make highly interactive games. Once they realised games were not easy to create with HyperStudio®, they settled for creative structuring of information. The internal student push for production quality in the EDUM classes was exacerbated by the external pressure of assessment. This was demoralising for some students, who had entered the course with minimal computing skills and were just gaining their confidence. Faced with considerable competitive pressure, the survival response was to complete the task at a basic level.

Through the processes of interactive multimedia production and construction, students were able to demonstrate the characteristics of higher order thinking described by Resnick (1987)— they followed a non-algorithmic path, faced knowledge, skill and process complexity, generated multiple solutions, coped with uncertainty, demonstrated nuanced judgment with media selection and adaptation, were required to self-regulate their thinking and put considerable effort into structuring information.

Class organisation required considerable flexibility on the part of teachers and students, in order to respond to varying levels of student progress with tasks, incidental emergencies such as the power failure in the first EDUM class, events such as Newsday with the G&T class or even the varied pace and content of group discussions. Peer support was a vital factor in maintaining class flexibility— students had to be able to give and take, share and care, explain and listen, encourage and accept support. They had to learn to plan their own tasks and seek help when they were stuck. For some students this level of self-regulation was their biggest challenge. The relationship between the students and teacher/s was crucial to the success of classes. Mutual respect was very important. If students were expected to be organised, the teacher had to demonstrate an equal level of organisation.

Problem solving and skill development were largely anchored in the context of student-driven tasks. In the G&T class animation emerged when some students had the need to learn the skill. Even though there was universal delight among all G&T students in the production of an animated sequence, many did not grasp the process when they were stepped through it— they could not repeat the process without considerable prompting. Others understood the principles of animation very clearly and were able to teach or guide their peers. The zone of proximal development was wide. Had the researcher made the assumption that animation was too hard for students of this age, they would have missed out on one of their most rewarding experiences. Some were ready for animation and dragged others along.

A similar experience occurred in the EDUM 212 group with scripting. The specific functional needs of particular projects forced students to expand their knowledge of HyperTalk® scripting. Design decisions created problem solving exercises which challenged the whole group— student collaboration was highly beneficial, as the solution to someone else's problem often provided a source of design ideas for other projects. Student achievement in the zone of proximal development was illustrated by one particular student in EDUM 212, who was not a competent scripter, but with considerable scripting support from the researcher, was able to implement far more sophisticated ideas about program structure and functionality than other students who were more competent with HyperTalk®.

Students in all classes exhibited frustration with the limitations of the available technology, once they became aware of multimedia production possibilities. The G&T class experienced shortage of hard disk space on some machines, shortage of RAM on all except one machine, difficulty moving large project stacks and they were quite critical of the quality of video snippets played on their "low end" colour machines. In the EDUM classes, the network speed bothered some, and digitised video quality was considered sub-standard, yet students in the main were very tolerant of variations in image and sound quality.

The similarities between EDUM 221 and EDUM 212 related to the common goal of skill development in interactive multimedia production, which was simply experienced at different stages of relative expertise. Once students in EDUM 212 had developed basic resource production and authoring skills, they were able to engage in a long term individual project. In this way they began to share a deep process of content immersion and construction with the G&T students.

Although each class shared these common process outcomes, the differences between them were marked, especially with regard to the nature of required resources and the emphasis placed on them. In Chapter Three, the paradigm of teacher, student and designer was introduced in the model of Squires and McDougall (1994). The designer was an educational software designer, who supplied the class with the key resource—educational software. The presence of machines to run this software was understood.

In the EDUM and G&T classes, the same functional trio was present— teacher, student and designer, but not as three separate entities. Both teachers and students functioned as designers. The key resources were people, media, tools and special machines.

The following chapter embraces the broad concept of interactive multimedia and learning, in order to view the differences between the typical classroom in which educational software is used, and the classroom in which the students are the multimedia designers. As the EDUM and G&T classes indicate, there is a further possible distinction which needs to be made— between students as multimedia production experts, and students as knowledge construction experts.

# *Chapter Six - An Interactive Multimedia Learning Framework*

## *Introduction*

The three actor paradigm of Squires and McDougall (1994) focuses on relationships between teacher and software designer, teacher and student, and software designer and student. This paradigm was developed as a teachers' guide to support the processes of choosing and using educational software. The emphasis was on the *use* of commercial software. When the learner is moved to centre stage (Schank and Cleary, 1995) and focus is placed on what they are actually doing with the software, the question can then be asked:

Should the learner be a software *user* or a software *producer*?

If they are a software *user*, their actions may encompass the full range of activities offered by software designers, from passive guided direction in prescriptive environments through to simulations and open active gathering and re-construction of multimedia resources in democratic information landscapes (Schweir, 1995). What they learn and how widely they use that knowledge or skill or strategy is a function of the context of program use— the learner extracts from a program what sense they make of it, not what use the designer intended (Streibel, 1991):

> *" ...the coherence of the learner's experience in this situation is not tied in essential ways to the instructional designer's intent (no matter how detailed or explicit these intentions are spelled out as instructional objectives) nor to the instructional plan built into the instructional system. Rather, the coherence of the learner's instructional experience is tied to the sense that such a learner constructs out of the actual situation (of which the instructional system is just a part)." (Streibel, 1991, p123)*

If the learner is a software *producer*, the question can be asked:

Why is the learner producing interactive multimedia software?

If their focus is on the development of an interactive multimedia software *product*, then the emphasis will be on learning about interactive multimedia production as a body of knowledge with an accompanying set of skills— a situated and authentic activity which synchronises learning and doing, yet an activity in which the acquisition of content knowledge is a fringe benefit. This equates with designer as learner (Jonassen and Reeves, 1996). The cognitive load of using many production tools may be very high.

If their emphasis is on the learning which occurs through the *process* of interactive multimedia construction— learner as designer (Jonassen and Reeves, 1996), then the nature of the product is far less important than the knowledge construction process which the learner experiences along the way. Less emphasis is placed on the refinement of production skills and more emphasis is placed on student initiated design and development with just-in-time skill support. The cognitive load of the construction tool should be minimal to permit the learner to focus on knowledge construction.

In the typical classroom, especially one which incorporates collaborative and cooperative learning activities, both teacher and students fluctuate between the activities of teaching and learning. In order to discuss the differences between the EDUM and G&T classes in the broader framework of interactive multimedia and classroom learning/teaching, the possible relationships between learners and interactive multimedia can be used as a basis for establishing a 3x2 grid. This common technique for brainstorming often yields some interesting results. The categories which are defined provide a systematic means of discussing the issues. Like the model of Squires and McDougall (1994), this framework should provide stimulus for further discussion. It is not an end in itself.

## 6.1 General Framework for Multimedia and Learning

Two activities on one axis are teaching and learning. This does not equate with teacher and students. Both teacher and students are involved in the activities of learning and of teaching, especially in a cooperative or collaborative situation.

On the second grid axis, the distinction is made between use of pre-existing educational interactive multimedia products and student production of interactive multimedia. Within the latter category, the reason for production then distinguishes between a focus on product development, and a focus on the significance of the construction process. The relationships which emerge are presented in *Table 6:1* on the following page.

The three models which appear in *Table 6.1* are:

- *Model A* —Teaching/Learning Through Use of Interactive Multimedia Products
- *Model B* — Teaching /Learning About Interactive Multimedia Production
- *Model C* — Teaching/Learning With Interactive Multimedia Construction Tools

| | IMM Use | IMM Production | |
|---|---|---|---|
| | | For Product | For Process |
| | (Model A) | (Model B) | (Model C) |
| *Teaching* | Teaching Through Use of IMM Products | Teaching About IMM Production | Teaching With IMM Construction Tools |
| *Learning* | Learning Through Use of IMM Products | Learning About IMM Production | Learning With IMM Construction Tools |

*Table 6.1: Cross-grid of Teaching vs Learning, Use vs Production of Interactive Multimedia (IMM)*

Each complementary relationship will be discussed in turn, looking at the nature of required resources, the pressures and practical difficulties of implementation, the unique processes and the range of potential process outcomes. *Table 6.2* on the following page summarises some of the key issues presented in Chapter Three and relates the proposed models in *Table 6.1* above to instructivist and constructivist software styles represented in *Figure 3.2 (p86).*

## 6.2 Model A - Teaching / Learning Through Use of Interactive Multimedia Products

Interactive multimedia products represent one category of software which may span positions A and B on *Figure 3.2.* They may range from highly instructivist and didactic packages which offer the learner little freedom and the teacher little involvement in the learning process, through to highly interactive information landscapes which offer the learner a set of tools with which to extract then construct their own knowledge structure and determine their own learning tasks. The nature of the product varies in accordance with the content, the anticipated level of schooling, and the software designer's views on learning theory, which translate into overall product structure, interface and learning strategies.

This model embraces the typical use of interactive multimedia and computers in the classroom. The researcher's experience in this model is not from the perspective of the classroom teacher using such software, but the perspective of the software designer, involved in the design and development of a number of major projects.

*Table 6.2: Proposed Models and the Teacher/Designer Relationship in Figure 3.2*

| Designer Control | Software Style | Teacher/Designer Relationship | Teacher Satisfaction | Teacher Skills & Knowledge | Relationship to Figure 3.2 | Relationship to Table 6.1 |
|---|---|---|---|---|---|---|
| High | Standalone<br><br>(Instructivist) | Independent | Highly variable; can be threatening | Management of machines & software use | Position A | **Model A** |
| Medium | Information Landscapes<br><br>(Constructivist) | Collaborative<br><br>Design<br><br>or<br><br>Implementation | High due to involvement once role is understood<br><br>Role in METACOGNITIVE SUPPORT | Design— offers content knowledge & strategies<br><br>Implementation— designs tasks & gives metacognitive support | Position B | **Model A**<br><br>**Teaching / Learning Using IMM Software** |
| Low | Software Tools<br><br>(Cognitive Tools) | Interdependent<br><br>Tool designer is also a teacher<br><br>Teacher designs tasks for tool use | High<br><br>Role is Instructor if the focus is on PRODUCT development | High technical, creative and theoretical competence required | Position C | **Model B**<br><br>**Teaching / Learning about IMM Production** |
| | | | High<br><br>Role is Facilitator if the focus is on PROCESS | Experience using the cognitive tools for knowledge construction | Position C | **Model C**<br><br>**Teaching / Learning with IMM construction tools** |

## Teaching Through Use of Interactive Multimedia Products

The work of Squires and McDougall (1994) is anchored within this model, aimed at supporting teaching through use of educational software. Squires and McDougall raise concerns about the teacher's ease of *selection* of appropriate software.

A teacher has to deal with many pressures as they select and purchase a software product— software compatibility with available hardware; a meaningful relationship between content and the curriculum; an appropriate level of learning outcomes; a range of learning tasks within the package to foster repeat product use.

Once software has been purchased by a school, the teacher is then faced with a host of practical difficulties— lack of familiarity with the product which causes personal concerns; difficulty predicting the amount of student access time required, particularly for a multi-step learning task; inability to access the computer facilities in a flexible manner to match student needs; evaluation of learning outcomes— the more democratic environments with multiple tasks challenge both teacher and students to design alternate forms of knowledge representation for a wide variety of learning outcomes.

The nature of learning outcomes will depend upon wise teacher selection, use and support of software to meet the needs of their learners. To maximise creative use of educational software, teachers should be familiar with a product and its associated technical and management needs— software loading, lab bookings, flexible class organisation and acceptance that technical problems are inevitable from time to time. Experience warns the technology literate teacher that a backup strategy is imperative in case of power failure, and also challenges him/her to turn such situations into problem solving exercises for the class.

Whether they have prior experience with software products or not, teachers who have the opportunity to collaborate with software designers can gain a lot for themselves and their students in the process. Teachers can be content and strategy experts in the design phase or in classroom implementation, providing designers with essential feedback.

Interactive multimedia software for classroom use provides the teacher with a bounded and stable set of resources. More recently, classroom access to the World Wide Web (WWW) has enabled this source to expand to global, unbounded and unstructured dimensions. It has provided the teacher with an alternate source of "software". The issues of information representation, access, interactivity and user control which are frequently discussed with CD ROM based products are equally valid for Web based material (Hedberg, Brown and Arrighi, 1997).

Teaching strategies for learners accessing the wealth of Web material need to emphasise the importance of information appraisal, selection, organisation, structuring and communication of ideas in the solution of meaningful tasks. The nature and source of these tasks (whether teacher or learner generated) help determine their relevance, complexity and ability to promote a deeper orientation to learning than simple surfing, rote learning and manipulation of meaningless content.

### *Learning Through Use of Interactive Multimedia Products*

From the learner's perspective, the issues are less cognitive and more affective. Students may experience a range of pressures and practical difficulties in the use of commercial educational software, such as :

- dislike of the software— this may be due to some form of computer phobia, or fear of appearing to be less able than classmates
- task completion pressure—the student may not perceive any task relevance, yet they feel compelled to go through the motions of the task as a diligent student. Content learnt in this manner may quickly join the ranks of inert knowledge. Such task completion focus can encourage shallow processing and grade rather than learning orientation.
- inappropriate social grouping—some student combinations may raise social barriers to learning— the student who dominates the mouse or group decision making process may discourage others from engaging in any form of software initiated learning. For group work, competition needs to be replaced by collaboration and cooperation. Until students learn such skills, many group exercises will be far from productive for all group members.
- absenteeism— when a student misses one phase in a multi-step process, they are often unable to make up the ground in an equivalent manner if computer access is not flexible. Computer confidence can rapidly wane relative to classmates.
- task completion time— learners vary enormously in the pace with which they can accomplish a task. A group of students sharing one machine usually vary in the time they take to read content on a screen, or in their ability to comprehend material presented in audio or video format. Group maturity has to be high to permit honesty when students don't understand something.
- variations in information input preferences— some students will find it very difficult to work in a noisy computer laboratory. Others may need to talk everything over and listen many times to audio information when they are required to take notes. For some students, exposure to computer monitors for

any length of time causes physical distress such as eye fatigue. Others with impaired hearing or sight may be disadvantaged.

While practical difficulties may be generalised across computer use, the nature of student pressures and learning outcomes is often a reflection of the general classroom climate— the teaching/learning philosophy of the teacher. The amount of teacher involvement in learning initiated or facilitated by software use is largely determined by the relationship between the educational software designer and the teacher— an issue which was discussed at length in Chapter Three. Theoretically, the more student control the designer has, the less contribution the classroom teacher can make to the learning experience. If the designer allows the learners freedom to navigate, extract and reconstruct media elements, they are inviting the teacher to be heavily involved in the metacognitive support of this process.

The teacher is not powerless in the relationship. At one extreme, they may make very creative use of highly didactic software by using it as one small option in a cluster of engaging student-driven activities. At the other extreme, they may choose not to accept the designer's offer to support students when they are using more democratic, multi-use packages. Like tools, any software can be used poorly. The inherent benefits of software use reside in the environment the teacher sets up, as much as the environment which the learner is allowed to experience by the designer.

Learning through use of commercial software is therefore an individual experience. When the teacher selects to use an instructivist prescriptive package, student awareness of the mental model of the program is important to reduce the cognitive load of navigation and allow them more active involvement in the tasks (Sims and Hedberg, 1995). Highly didactic software is usually unfolded as a linear stream of screens, but unless an overview of objectives and purpose is provided at the beginning, it is a matter of luck whether the logic flow of the constructor matches that of the student.

Students usually work through this type of software as a single user. Learning objectives are often tested throughout software use as a means of determining access to more complex content, or are tested in some form of motivating game. The position a student reaches in the pre-defined pathway becomes a source of competition, with winners and losers. This merely adds to the stress of those students who are less comfortable with computers, and diminishes the attention given to the content to be learned. Limited user options usually call for little discussion and this style of software is seldom appropriate for small group use. Unless students are challenged to express the material they have learned in their own words, it is difficult to stimulate any deep processing of the material. If students perceive little relationship between the objectives of the software and current topics of study, the use of such software may be regarded at best as fun, and at worst as a waste of time. This attitude often transfers to the use of more appropriate software, and can lead to the student perception that all educational software has little classroom relevance.

As the designer relinquishes control over user movement and decision making in their software design, linear and hierarchical structures are replaced by hypermedia landscapes and simulations. Graphics can assist student orientation and awareness of functionality, but several dilemmas remain for them— how they access the landscape, what their task is, what they can take away to remind them of the experience and how they can re-structure what they have gathered. Essentially a landscape is presented to provide resources in a particular context. The student can deconstruct and reconstruct these resources according to the nature of their task, whether that task is suggested by the teacher, the software or is self-generated. Simulations allow direct experience with manipulation of variables, but it is crucial that students have the opportunity to record what they discover, and are able to repeat that experience until it is very clear in their minds.

To compensate for the decrease in designer control, students need an increase in the quality and diversity of teacher and peer support to maximise potential learning outcomes from software use. The collaboration required between software designer and teacher/students leads to more active involvement of the teacher and students throughout a more extended learning process, which may incorporate the discussion of possible strategies prior to software use, assistance with problems or challenges throughout software use, and analysis and reflection on findings after software use. The aim of the software is to provide resource material which can be used in a flexible manner, and to stimulate the generation of unique teaching/learning strategies which capitalise on the benefits the computer can offer.

More open tasks associated with democratic software encourage small group computer use and peer collaboration. Students have more freedom to interpret tasks in their own way and incorporate their values and attitudes into solutions which may call for complex answers. The level of learner engagement is often much higher than memory and application— necessitating higher order thinking and integration of complex factors in the construction of one solution to a problem. Complex problems can be studied in isolation, or used as a springboard into comparison with, or identification of, local issues.

While the designer risks the negative scenario of poor teacher support when they relinquish control of the learner, this is offset by the positive scenario of increased student-regulated learning. Unlike the more prescriptive environments, these democratic learning environments permit the learner to be creative and demonstrate what they are capable of, given access to information and productivity tools. They support a range of learning styles and strategies, yet still maintain ease of use to increase product flexibility and sustained access. Most schools can't afford to purchase educational software packages which don't offer flexibility and a range of task options.

Software designed from a more student-driven constructivist perspective need not be used by a group, however, the individual user needs to display the motivation and metacognitive skills of a self-regulated learner to gain maximum benefit from the software without peer support. Group use may provide a discussion forum for suggestions, ideas and debate, a multitude of learning and problem solving strategies to share, and immediate personal feedback on all communication channels (auditory, visual, body language). Such group benefits are not automatic— they are only achieved once group members have acknowledged the need to refine such skills as negotiation and collaboration.

The main limitation of CD-ROM based information landscapes is the permanence of data. Once you have solved all inherent problems within a fixed landscape, no matter how creative and advanced the data management and manipulation tools, there is no new data with which to work, and no regular update of information to note current trends. As a "microworld" in which to explore and develop skills in information transformation and interpretation, CD ROMs provide high quality material with support. As such they are an excellent environment in which to develop these skills, particularly when there is the opportunity to combine inbuilt support with real–time personal group benefits.

When the learner is able to access the unbounded multimedia resources of the WWW, they require self-discipline and sound metacognitive strategies to pursue a particular task and remain focused. They are challenged to refine any computer skills and strategies they may have developed on bounded constructivist microworlds to maximise the potential benefits of access to an overload of resources. Practice with the metacognitive tools provided in constructivist software allows them to reflect upon, re-construct and personalise the electronic material they collect while Web surfing.

## 6.3 Model B - Teaching / Learning About Interactive Multimedia Production

This model is one of two which relate to position C on *Figure 3.2*. In this model the teacher aims to skill students in interactive multimedia production, and employs a range of software tools. These tools are software applications which are used by students to create and integrate their own resources in a multimedia product. Both EDUM classes (EDUM 221 and EDUM 212) were anchored in this model. Pre-service primary school teachers were skilled for product development in their future classrooms.

### Teaching About Interactive Multimedia Production

Interactive multimedia production is an extremely complex activity which broadly encompasses three domains:

- resource production
- instructional design
- media orchestration

Each of these domains requires high level thinking of a specific nature. Resource production is the creation or selection and digital conversion of media elements. While creative and artistic skills are required, the digitising process involves the use of a wide range of complex applications and technical equipment. Certain linear procedures must be mastered for success. Resource production requires creative flair and technical competence which emerges through sustained experience.

Instructional design taps a wealth of learning theory, message and interface design to ensure coherence of software structure and achievement of design objectives through a systematic design process. Many conflicting concepts must be mapped out and balanced. Instructional design requires global systems thinking and conceptual competence.

Media orchestration creatively blends the media elements of resource production into an integrated unit based on instructional design theory using an authoring tool. This process calls for significant skills in analysis, synthesis and evaluation of content, structure and interactivity, in addition to programming skills and a logical approach to program construction. All that effort can be futile if the standard of graphic design is not high enough to permit user focus on the key elements. Media orchestration requires creative flair, an ability to deal with complexity, and acceptance of the frustration of a recursive editing process.

The major pressure on anyone teaching interactive multimedia production is a constant sense of inadequacy in a complex and rapidly evolving field. It is highly unlikely that any one teacher will possess a full range of technical skills, a deep theoretical and conceptual appreciation of the highly situation specific process of instructional design. artistic tolerance for ambiguity, and the creative flair to suggest multiple solutions.

The field complexity presents problems with sequencing and presentation of material. Students are required to develop skills, improve conceptual understanding and develop creative expression. Given the individuality of students and the considerable variation in learning styles, there will never be one best way to introduce students to interactive multimedia production. Thus the inevitable feedback of intense learner frustration is likely to add to teaching pressures.

If the teacher decides to teach technical skills first, due to the extended practice required to automate skills and relieve the cognitive load, then students will not be conceptually aware of the design principles required to integrate digitised resources in anything but an intuitive way. However, partnering the enhancement of creativity with the development of technical skills is beneficial. Tasks which require multiple solutions can be encouraged to promote diverse multimedia expression while students are developing production skills.

Such initial emphasis on design diversity provides a counterbalance to the rigour of traditional instructional design models and interface design theory, once this conceptual material is covered. Instructional design theory tends to suggest "best practices" of interactive multimedia orchestration and often prescribes interface rules which limit creative freedom. Early focus on creativity and diversity helps the teacher to convey the need for balance between traditional design and examples of outstanding products which often break many of the design rules.

*Reflections on EDUM Classes— 221 then 212 :* The researcher experienced a range of differences between the two EDUM classes, in terms of unique resource requirements, processes and process outcomes. There was considerable difference between the introductory course in interactive multimedia production, which was focused on tools. skill development and theory, and the more advanced course, which permitted students to use the tools and production skills to immerse themselves in a major individual project.

*Resources* : *Table 6.3* below presents a summary of the key differences between resource requirements for EDUM 221 (a preliminary multimedia production course), and EDUM 212 (a more advanced interactive multimedia production course):

| *Resources* | *EDUM 221 - Early Production* | *EDUM 212 - Later Production* |
|---|---|---|
| *People* | Teacher and peers supported skill development. | Peers and content experts were more dominant than the teacher. |
| *Machines* | Machines did not limit production. Power and network complexity were daunting to students. | Machines did not limit production. Students had a better mental model of the network. Different students were pushed in resource production by the specific needs of their project. |
| *Media* | Images were widely accessed and scanned. | Media varied with each individual project— most were information landscapes; one was a text engine. |
| *Teacher Tools* | Print material was vital, and video recording was a great technique for more complex tasks. A Performance support tool was vital to the use of HyperCard®. | Print material was vital for scripting. Video could be used as a tool to report student progress. Performance support tools had to be tailored for scripting needs. |

*Table 6.3: Comparison of Resource Requirements for Classes EDUM 221 and EDUM 212*

The initial course (EDUM 221) focused on teacher and peer support for skill development, was only restricted by available hardware in terms of the cognitive load of its use for novice producers, relied heavily on images as the source of media, and utilised teacher tools of print, video and software variety extensively. Print tools offered immediate support in class, while video tools recorded a demonstration or problem solving episode for subsequent access. Software tools to link, model and reflect student work were effective focal points for interactive class demonstrations. The performance support stack for HyperCard® tutorials provided students with a means to explore the scripting power of HyperTalk® from a vantage point of automated media scripting. Teacher tools were vital to maximise the opportunities for learners to move at a more individual pace and to reflect on certain processes.

The resource requirements of the later course (EDUM 212) were driven by the individual needs of students. These were determined by their specific project focus. Peers were as important as the teacher in support of skill development and discussion on project ideas. Media were selected by each student according to his/her project theme. This drove some students to explore special effects and develop more advanced resource manipulation skills. The teacher tools supplied to this group were tailored for individual scripting requirements, though cross fertilisation of ideas for code functionality was common. The pace of class progress was determined as much by interactions among students as interactions among students and the teacher.

*Processes:* The common classroom processes and shared process outcomes across both production (EDUM) and construction (G&T) classes were highlighted at the end of chapter five. They included high levels of motivation and extended task engagement, individual resource production, individual and paired skill development, creative and cultural freedom, support for the expression of varied talents and individual differences, higher order thinking and anchored problem solving. *Table 6.4* on the following page lists the processes which were unique to each EDUM (production) class— unique to that particular stage of student production.

*EDUM 221 :* The practice of skilling student "experts" in resource digitising in EDUM 221 was an effective strategy for teaching complex skills with limited equipment and a single teacher. More importantly, it ensured not only that the evaluation of skill mastery was through the authentic activity of teaching another student, but also that this teaching activity was repeated a number of times. Rapid changes in digitising hardware and software tend to devalue student knowledge of a single technique, unless they understand the key stages of the process in a conceptual manner and can therefore transfer them to an alternate system. Students can reach this point more easily when they are required to explain the process to others in their own words, and field a host of questions. As digitising "experts", students in EDUM 221 were required to explain a particular digitising process to a range of peers over a considerable period of time.

The initial student development of authoring skills was conducted cooperatively as a paired exercise in HyperStudio®, following silent video demonstration then the provision of print support material. The paired arrangement proved a popular move, as it was less threatening than individual work and more conducive to experimentation and discussion of problems. When the subsequent shift to a small individual project task was accompanied by a shift to HyperCard® as an authoring tool, a real limit to student expression of project design was identified. This was the need for students to develop some scripting skills with HyperTalk®.

HyperStudio®, with its automatic scripting, had sheltered the students from design decisions outside the scope of the application's inbuilt options. Due to the lack of automation of the programming language HyperTalk® within HyperCard®, students had to design the overall structure of their own stacks, generate the navigation options to accompany that design, and customise button functionality. They were soon aware that as multimedia producers they would need to understand some of the fundamental principles and structures of a programming language.

| *Course* | *Unique Processes* |
|---|---|
| *EDUM 221*<br><br>Introductory Course in Multimedia Production | • demonstration of digitising skills to a panel of subsequent "experts"<br>• demonstration of construction skills either live or on video<br>• individual and paired completion of construction tasks<br>• comparative discussions on HyperCard® and HyperStudio®<br>• discussion of instructional design theory<br>• demonstration of software examples<br>• reflective technical sessions<br>• whole group collaboration<br>• cooperative tasks (HyperStudio® task and group project) |
| *EDUM 212*<br><br>Major Individual Interactive Multimedia Project | • tailored scripting demonstrations<br>• negotiation of tasks or assessment<br>• individual oral reports on progress<br>• video recording of diary reports or class discussion<br>• self-monitoring and regulation of a major project<br>• individual scripting support<br>• synchronised tutorial for animation<br>• problem-solving with equipment |

*Table 6.4: Comparison of Unique Processes in Classes EDUM 221 and EDUM 212*

The co-lecturer for EDUM 221 presented a series of lectures on instructional design theory during the initial weeks of the course when the researcher was skilling students in media digitising. The lectures often included demonstrations of commercial software packages to illustrate the design principles discussed.

Reflective technical sessions were held at the beginning of the practical component of EDUM 221 classes. They focused on relevant problems some students had already experienced and therefore others were likely to encounter. The "Show and Tell" sessions permitted students to share technical knowledge, production strategies, problems and experiences. They also encouraged reflection upon the whole production process.

The Group Project was planned as an opportunity for students to experience the design process a second time within the course. While it did not serve this purpose due to the large group size and time limits, nevertheless it did provide students with the opportunity to use digitising skills and experience the benefits and disadvantages of team production. The individual projects had been conducted in a collaborative manner—students were happy to share experiences and offer advice. The group project was cooperative, and thus required delegation of duties. This left some students without much to do at the end, and a lack of sense of belonging. The sense of group ownership moved from the "thinkers" to the "doers".

*EDUM 212:* The unique processes of the more advanced production course reflected the nature of a small class group where individuals were able to pursue their own projects. The class was driven by the various needs of different students. Each production pathway was different, so the nature and timing of assistance was unique to each student. The researcher's role as teacher was to anticipate, monitor and respond to these various student needs. Scripting demonstrations were therefore tailored according to the specific functional requirements of particular projects.

The project topics and the components of assessment were negotiated in this course. Students were initially involved in the discussion and listing of assessment criteria, then ultimately contributed to overall project marks through peer assessment. Between these times, they reported back to the class via individual oral reports, or made more permanent recordings for subsequent reflection using the video recorder.

The release of class planning from teacher/researcher control meant that each student had to learn to monitor his/her progress, and regulate his/her project. The teacher/researcher was available for individual scripting support either within or outside class time, but it was up to the students to organise this support.

Due to the ease with which students handled resource digitising skills, the researcher/teacher introduced a synchronised tutorial for animation, to complete the set of skills required for multimedia production. The students were not particularly impressed with step-wise oral instructions. The researcher felt these students were now competent at introducing themselves to new applications, and favoured the individual pacing of self-regulated learning.

One particularly notable feature of many classes in EDUM 212 was the amount of time students spent solving perceived problems with equipment, and the cognitive flexibility they exhibited in finding solutions. Many of these problems were related to inadequate understanding of a sequence of steps in a process; some were related to equipment malfunctions. The initial fear of equipment malfunction expressed in EDUM 221 as a negative response to any untoward event, disappeared in EDUM 212 except at times when the pressure of a deadline was intense. Otherwise, when there was adequate time to resolve the problem, the students would challenge each other to find a solution, or attempt repeatedly to achieve a positive outcome.

*Process Outcomes* : ***Table 6.5*** on the following page compares the process outcomes of the two EDUM production courses. Discussion begins with the introductory course.

*EDUM 221* : At the end of their course, these students were competent at resource digitising, were able to utilise a broad range of software applications, could orchestrate media in a low level authoring tool such as HyperStudio® or HyperCard® with a media palette, and had experienced a considerable rise in self-esteem. The researcher felt this was directly attributable to the improvement in multimedia production skills experienced throughout the course. Students had initially doubted they could achieve the results they did, and were very proud of their final achievements .

Most students spent at least 3-4 hours in the interactive multimedia laboratory each week. They were immersed in the technology, and seldom took the opportunity to leave the room for a break. The paired task in HyperStudio® gave them a partner with which to work, and the "expert" status with resource digitising gave them a collective within which to share experiences. What did concern students was the nature of the assessment criteria. The mastery grading of the HyperStudio® task was initially popular until some students began to invest more time and effort than others. They were disappointed that the outcome differences they perceived among HyperStudio® stacks were not reflected in grade differences. When grades were awarded in the individual HyperCard® task, to acknowledge differences in skill, application and effort, the principle was not so popular, particularly due to the impact of stiff competition.

| Course | Unique Process Outcomes |
|---|---|
| *EDUM 221*<br><br>Introductory Course in Multimedia Production | • students developed a range of resource production and multimedia construction skills in a teacher-directed environment<br>• students were able to learn certain production skills through the process of teaching their peers<br>• students experienced a considerable rise in self-esteem<br>• students developed awareness of multimedia authoring tools as a category of application software<br>• students were immersed in the computer laboratory environment for a considerable period of time each week (at least 3 hours)<br>• students expressed concern regarding assessment criteria<br>• students were competent at interface design appraisal with commercial products, but did not apply these principles to their own products |
| *EDUM 212*<br><br>Major Individual Interactive Multimedia Project | • students extended production skills according to the needs of their project, in an environment where the teacher was a facilitator<br>• students experienced a considerable rise in self-esteem specifically related to information technology<br>• students developed mental models of the networked laboratory environment and the whereabouts of their resources<br>• students experienced the process of peer assessment<br>• students developed metacognitive skills in the planning, organisation and management of project materials<br>• students developed cognitive flexibility with application software— they were able to select the best application for the particular task<br>• students were immersed in the computer laboratory environment for a considerable period of time each week (at least 4-6 hours)<br>• students exhibited a flexible approach to the technology, its problems and the development of a major project |

*Table 6.5: Comparison of Unique Process Outcomes in Classes EDUM 221 and EDUM 212*

While students in EDUM 221 became adept at analysing design inconsistencies in commercial products during the design lectures, they did not direct the same analysis at their own productions. The researcher has identified a number of possible reasons for this :

- the cognitive load involved in using the digitising and authoring tools was high. Students tended to concentrate on these activities since the outcomes were clearly positive or negative- they were assessed on mastery. Students were also aware that as future teachers they would need to possess these skills.
- the affective domain was extremely important in final performance— how students felt about their abilities with the technology was crucial to their productivity. Any untoward setback with a previously mastered protocol often amplified any negative feelings towards the technology (process), or worse, self-esteem with technical equipment. Subsequent success did not necessarily initiate a rapid reversal of these negative feelings.
- low levels of project content knowledge left students with an almost impossible task. While they were still grappling with facts, rather than deep conceptual understanding in their respective project domains, they were not able to develop clear mental models of that knowledge to present in their projects. The needs and the tasks in the design process were not clear. This simply compounded the cognitive load of new technical skills and conceptual design models.
- while some students exhibited metacognitive planning strategies, there was little evidence of subsequent monitoring, reflection and revision of plans. The application of design principles would require some global awareness of the product from a user's perspective. This would require the ability to observe the product "from a distance". If students were not familiar with recursive revision of work in traditional text mode, it was unlikely they would spontaneously develop that habit in multimedia format.
- limited student experience with interactive multimedia interface metaphors and instructional strategies meant it was difficult to apply such unfamiliar and rather abstract principles to the first major project in a restricted time frame.
- students did not exhibit the desire to conform to any pre-conceived design. They appeared to revel in creative diversity.

*EDUM 212 :* Some of the process outcomes of the more advanced multimedia production course were discussed in conjunction with class processes. Of note amongst the remaining EDUM 212 process outcomes in *Table 6.5* is the student development of mental models of the laboratory network, and the whereabouts of their resources.

This was closely related to the development of metacognitive skills such as planning, organisation and management. Students developed a flexible approach to the use of hardware and software components of computer technology, to time and resource management, and to the iterative design of their major project. There was little indication, however, that students were any more active in the self-analysis of design inconsistencies.

The teaching pressures associated with conveying and supporting the complex task of interactive multimedia production can be compounded when there is a need to evaluate specific learning outcomes. It is difficult to strike a balance so that the motivating effect of evaluation does not induce such student stress that the negative feelings are directed towards the technology. It is also very difficult to place a mark on student work as a multimedia product, when each student has experienced a different process and travelled a different distance in terms of personal growth and acceptance of the technology. The peer assessment process in EDUM 212 was an attempt to balance this assessment load. If nothing else, it enabled students to experience the difficulty of placing a mark on a creative exercise.

### *Learning About Interactive Multimedia Production*

*Researcher Reflections :* Due to the researcher's involvement in a number of interactive multimedia projects throughout the course of this study, many of the following comments are derived from personal reflections on skill development via cognitive apprenticeship. The projects and their detailed diary notes may be accessed as the birds in the "PhD Walk" in *The Garden*. At various times the researcher was involved in programming, graphics and instructional design.

From the perspective of a novice, interactive multimedia production is a vast enterprise. When learning about interactive multimedia production, it is difficult to cope with the conceptual knowledge and range of skills you have to acquire if you wish in a very modest way to become a self-sufficient producer. Commercial multimedia production is conducted by multi-disciplinary teams, and team members are often multi-skilled. To meet production deadlines and work within a strict budget, successful project teams usually follow strict rules of project management. The development of a commercial software product is an extremely complex process.

The range of skills is daunting, yet for many people it is also strangely liberating. No-one will be good at everything. The more skills you attempt, the more chance you have of identifying hidden talents, and recognising similarities and differences in process. The more media you consider, the more you appreciate the expertise required to select appropriate media to convey a particular message. Some skills require logic, others test spatial ability, while others hone manipulative precision. Multimedia production is a highly creative process, and one which pushes you through multiple perspectives on any issue.

Why learn so many of these skills when projects are usually created in teams? Teamwork requires collaboration and cooperation. The former allows for multiple suggestions with a range of individual outputs— great for generating alternatives, while the latter requires delegation and interdependence— at some stage one person has to make particular decisions. Experience and varied skills maximise collaboration, and provide insight into the role and challenges faced by other team members. This understanding often helps avert conflicts.

With each project, team composition usually changes, therefore multi skilled team members often find they occupy different roles in different projects, according to the skills and nature of group composition. In small teams, one individual may perform several roles, while in large teams, there may be several people performing the one role, such as programming. The more you can cross disciplinary boundaries in learning about multimedia production, the more flexible your thinking style can become.

Frustration levels can be very high while learning production techniques, and the time investment can be considerable. The hidden enemy is chaos, if you don't become aware of the crucial need to do the simple things well—name files properly, organise resources, and record what you have done systematically so others are informed.

Learning about interactive multimedia production is active, and it is best orchestrated via a meaningful task. Individual skills can be practiced, but until they must be co-ordinated in a specific way in a particular task, the interactions do not become apparent. Flexibility comes from repeated exposures to the complete process. Multimedia project work is a very complex and ill-structured domain. Multiple small tasks are essential to avoid the tendency to overgeneralise after one large project.

*Reflections on Student Comments in Class EDUM 212* : The students who continued interactive multimedia production throughout semester two— the five students in EDUM 212, provided considerable feedback on the process of interactive multimedia project work from the learner's perspective. They were each engaged in an individual project for the entire semester. The following issues emerged from student feedback during this sustained effort:

- students experienced different patterns of difficulty with particular skills or concepts. There was no standard grading of difficulty for particular skills—

student response reflected the varied skill and knowledge base they brought with them. They required support material or peer assistance to individualise the learning pace.

- scripting was a major stumbling block to student expression of design principles relating to interactivity, rather than screen design. What students produced did not reflect what they would have liked to produce. That was clearly expressed in the final "Show and Tell" session. The design statements did not do justice to projects, and were no real indication of the final product. The formulation of a design statement which describes screen elements and conveys the interactive nature of those screens represents a writing genre which itself requires considerable skill and experience.
- scripting support was only of value when it was relevant and timely. Students needed support within the context of their project. This meant for some, the scripting demonstrations were of little value, merely enticing them to incorporate features as "bells and whistles" because they knew how. For others, the demonstration of a particular script for certain functionality opened up a whole new realm of user control within their program, and altered their design path. Table 5.2 illustrated the varied nature of scripting support for each student. The scripting demonstrations were aimed at providing general scripting support for those students who were competent at other programming languages, were not familiar with the specifics of HyperCard®, but were not prepared to ask about details. Not everyone is comfortable seeking support if they feel that makes them seem less competent in front of peers.
- video recording of project progress reports was valuable in helping students to express their concerns and clarify design issues. They were able to verbalise problems, which helped in two ways. Firstly, others could offer immediate feedback and suggest possible solutions. Secondly, it was not unusual for the students to solve their own problem once they were able to communicate clearly just what those problems were. Talking things out helped students focus on problem identification. This form of reflection through speech is not the same as written notes in a process diary.
- resource management was an issue which rapidly emerged as students generated copious resources. They faced the dilemma of file naming protocol, particularly on computers attached to resource digitisers such as the colour scanner. Common, ambiguous or non-descriptive names were a source of frustration when students were trying to find a particular file.
- conversation was important in classes. Project work was a whole language environment, and speech served many functions, not the least of which was

moral support. This was a collaborative group. Peer assistance was offered voluntarily, often at the expense of progress on the assistant's project. Peers were valued for their skill and knowledge, but their help was not sought unless it could be offered without any display of superiority.

- the addition of animation to the range of interactive multimedia skills placed many other skills in perspective. Students found animation exciting but cognitively very challenging. It demanded logic, precision and enormous amounts of patience for very small but extremely potent rewards. Though an animation task was required for assessment of skills, it would not have been appropriate to expect animation in the major project. Such a requirement would have been extremely stressful, and quite contrary to the student-centred nature of their projects. It may also have promoted gratuitous animation with little educational value.
- students rated teacher characteristics of good interpersonal skills and organisation more highly than technical skills and ability to provide support material. When they were asked to put themselves in the teacher's position, technical skills and support material were much more important. This has a lot to do with perceived need for technical competence prior to any teaching with computers.
- though each student in EDUM 212 had experienced the same introduction to interactive multimedia in semester one (EDUM 221), individual differences were amplified with the extended opportunity to apply the skills to a personally meaningful project over an extended period of time. It became apparent towards the end of the class that the next stage of development for these students was a group project, to introduce the team experience.

*What others have found :* Harel (1991b), in the Instructional Software Design Project (ISDP), set out to analyse a new set of conditions for learning fractions, Logo programming, metacognitive skills and software design. Harel emphasised the paradigmatic shift in her approach:

> *"This paradigm of work with children differs radically from traditional use of computer software (and programming) in schools in several ways. Most important is the* ***product design component:*** *The goal of the students' work is to produce a well designed product intended for use by others, to make an educational software package on the model of commercial software products. I have documented quite clearly that awareness of an 'end user' in the process of learning made a significant difference (even in the students' engagement with fractions!)" (Harel, 1991b, pxvi)*

Harel drew her study from a theoretical base of Piagetian constructivism, Papert's constructionism, Vygotsky's emphasis on the social nature of learning in the Zone of Proximal Development (ZPD) and Perkins' work on knowledge as design. Papert was distinguished from the other three theoreticians since he questioned the high value they placed on abstract and formal thinking:

> *"Unlike the other three, Papert is not attempting to find "best methods" for facilitating abstract thinking or for helping learners reach the formal and the abstract; rather, he wishes to create learning environments where both abstract and concrete (or soft, relational) thinkers could develop within and feel successful about their cognitive achievements." (Harel, 1991b, p31)*

Harel found that fourth grade students, working side by side one hour a day for four months on a software design project to teach younger students were:

> *"strongly motivated and fully in charge of their own learning; they appeared to establish sequences of learning and development that were an interesting mixture of Piagetian and Vygotskian processes; and they bore out Papert's and Perkins' theories of knowledge construction and learning." (Harel, 1991b, p341)*

Spontaneous student inventions were attributed by Harel to Piagetian constructivism, while the scaffolding of adults and peers which influenced student work was attributed to Vygotsky's ZPD. The computer programs played an important role as self-constructed objects-to-think-with— the basis of Papert's constructionism, while Perkins' ideas of knowledge as design were integral to the study:

> *"The processes of students' producing complex products, learning about large meaningful chunks of information through building instructional systems, identifying the purposes and structure of each component in that system, and creating interrelationships between components— processes that rarely exist in conventional education— had a crucial role in students' ability to establish strong relational networks between concepts, and to make their pieces of knowledge highly connected to each other." (Harel, 1991b, p344)*

Language and social communication were very important in the learning process. Language was used intensively as a means to communicate either with thinking tools (software and notebooks) or with peers. The length, structure and complexity of the projects enhanced the programming skills of students well beyond the skills of students engaged in usual Headlight Integrated-Logo projects, which lasted from several days to three weeks. Students acquired cognitive flexibility, control over their solution processes and confidence in their thinking. They demonstrated enhanced metacognitive skills of planning, problem-finding, monitoring and reflection.

Harel constructed an image of what she termed "learners as designers" (or "design for learning"), based on the following reasoning:

- Design motivates learning - learners find relevance in the work.
- Designers make things happen - an active process.
- Design evokes self-knowledge. Designers make personal connections between the affective and the cognitive.
- Designing a product promotes consideration of intended users, clients, customers— the community of others that designers serve. Designers learn by teaching.
- Design is integrative and holistic. (Harel, 1991b, ppxviii-xx)

The 17 students in Harel's study were using the Logowriter programming language. They designed, programmed and evaluated a collection of interactive screens to teach third graders about basic concepts of fractions. The project was open ended, but included a series of routines— students planned and designed in their Designer Notebooks before computer use, then recorded reflections and noted problems after computer time. Several focus sessions were run on software design, Logo programming and representing fractions, though the exact nature of classes was not pre-planned by the class teacher or the researcher:

> *"In general we had no specific plans for the project's sequence, or for our presentations and focus discussions; rather, they were initiated by the teacher or by me at times when they were relevant to the students' work or problems, or at the students' request." (Harel, 1991b, p17)*

Multimedia design and production tools were not available at the time of Harel's study. She made several recommendations about programming and tools:

> *"In the 1970s, when Logo was developed, researchers and educators thought that the main purpose in children's programming was the "cognitive gains" from the programming activity itself and the transfer of those "thinking skills" into areas outside of programming. However, ISDP points in another direction— towards programming as a means for learning and building other things, formulating ideas, and constructing knowledge. Researchers and tool developers will need to investigate this issue deeply as they think about the next generation of programmable tools.*

*... educators need to think about these systems as constructive tools for* ***knowledge reformulation****. They must structure projects in such a way that* ***children*** *become the explorers, the designers, and the builders with these tools." (Harel, 1991b, p390- 391)*

The five students in the semester two course (EDUM 212) shared many experiences with the students in Harel's study. They were immersed in an individual major project for the whole semester. This was an open, self-regulated process of knowledge reformulation as designers. Students chose their own project topic, worked collaboratively, received peer and teacher support on a needs basis and geared their product to the 'end user'. The differences between the studies are perhaps more informative:

- Skills— Students in EDUM 212 were required to display a much more complex array of skills in order to generate, manage and orchestrate text, image, sound and video resources. The varied nature of hardware and extensive array of software tools is not comparable to the use of a single tool such as Logowriter.
- Instructional Models— The range of software designs explored by students in the previous course (EDUM 221) was broad; students were faced with complex choices in their instructional design. Such complexity was not evident at the time of Harel's study.

Nicholson (1994) looked at the design strategies of a group of naive multimedia developers, given the task of using multimedia to produce a physics concept from a constructivist perspective. Students largely chose linear pedagogies according to the way they had learnt the material. Hypertext links and clustering at one level of the hierarchy were among the student attempts to make these programs "constructivist". Nicholson concluded that students understood constructivism within a classroom framework, but could not translate that to a multimedia environment, as they had not witnessed any examples of constructivist design:

*"It appears as if constructivist ideas are too complex to be adopted by beginning developers. Indeed, the lack of constructivism in the majority of multimedia packages suggests that it is either too difficult per se or that designers pay little attention to research about effective learning. As the merits of constructivist paradigms of learning are increasingly appearing in the education literature, it is incumbent on professional software developers to take note of the important messages about learning that the paradigm is giving us. To ignore this is to locate multimedia software firmly in the electronic book category and perhaps consign it to an interesting irrelevancy to mainstream learning." (Nicholson, 1994, p36)*

Nicholson did not present his understanding of constructivism, nor did he mention whether strategies for classroom implementation of constructivism were fully discussed with students. There was no description of the level of students' skills in multimedia production. If low, this would largely account for their lack of ability to focus on physics concepts and demanding constructivist design. Students, who are not great scripters, are unable to link material into structures much beyond a linear, hub or tree arrangement. Those who do not have a thorough understanding of the content at a conceptual level have difficulty constructing meaningful chunks to link in creative ways to permit meaningful user exploration and manipulation. Tools limit student capabilities. HyperCard® is a good example: the main complaint from "programmers" is that they can't see the object hierarchy, code is hidden from sight, and there is no visual representation of the structure they are creating. Students can't make the leap if they don't have the right software tools.

Squires (1996) discusses two salient features of constructivist learning— authenticity and complexity, and their translation to multimedia environments. Authenticity involves:

- a sense of ownership in learning which promotes reflection and metacognitive development
- engagement in comprehensive project based activities which are generative, interdisciplinary and complex
- expression of multiple perspectives

Complexity of a full stimulus environment allows the software user to explore and experiment in a more realistic environment, which contributes to the authenticity of the experience. Three design traps which are associated with attempting to implement authenticity and complexity in multimedia are superficial complexity, passivity and fantasy.

Considering the complexity of constructivist multimedia design, it is hardly surprising that Nicholson's students (Nicholson, 1994) were unable to meet his expectations as naive multimedia developers. What Nicholson may or may not fully appreciate, is that he placed his students in a wonderful constructivist environment as software producers. The software production process admirably satisfies the criteria of authenticity and complexity, and illustrates Papert's notion of constructionism, which is discussed more fully in the following Model. Nicholson's students may well have learned most about their misunderstandings in physics. Harel (1991b) expresses what many instructional designers can relate to in regard to software production:

*"My group was involved in designing interactive lessons about basic scientific concepts and processes. I realised that the amount of understanding and knowledge I had gained on scientific concepts and skills involved in that videodisc was probably greater than that of any future user of that videodisc system. My struggling with the raw materials, my discussions with the group, my thoughts about different ways of presenting a concept, the selections of video-clips and representations, the production of instructional sentences and feedbacks, my decisions about the sequence of screens, the design of graphic displays, and so on forced me and my group to learn, understand, and become involved in all aspects of the content and skills presented in the videodisc and the interactive software." (Harel, 1991b, pp 23-24)*

Teaching and learning about interactive multimedia production are both complex exercises. There is no doubt that much learning takes place on at least two fronts:

- learning about multimedia production— a complex of skills, theory and creative expression
- learning of project content

Commercial standards of multimedia production are very high. Such production is usually carried out by highly skilled teams of developers, who have invested considerable time and effort to achieve their level of proficiency and experience. In support of constructivist learning in an environment with computers, Harel (1991b) emphasises the importance of a product design component, awareness of an end user, and the need to place children/students in the design seat.

The complexity of instructional design in a multimedia environment with a specific *product* focus reduces the likelihood that many students will gain the benefit of such an experience. The hardware and software resource requirements are sizeable and ever changing, the initial skilling process is very time consuming, the cognitive load of the software tools is considerable, and students have trouble dealing with the simultaneous demands of conceptual, creative and technical growth.

What is questioned by the researcher, is whether the focus should be placed on student development of products, or whether meaningful learning and the benefits of the ISDP type of environment, experienced more by EDUM 212 students, can be provided with a less demanding but potentially equally engaging *process* focus. The following model explores this option.

## 6.4 Model C - Teaching / Learning With Interactive Multimedia Construction Tools

This model is the second one to relate to position C on *Figure 3.2.* The teacher employs a range of software tools including low level interactive multimedia authoring or construction tools. The aim is to focus on the *process* of interactive multimedia construction as a means to facilitate learning. A range of software applications may be used by students as tools to create resources. The authoring tool permits them to construct an evolving multimedia representation as their understanding develops. The G&T class fits this model.

The emphasis is not on development of a polished product which satisfies commercial standards of instructional and interface design. There is no specified 'end user' in terms of a single target audience, apart from the student or group of students producing the software. The researcher asks the question— will the emphasis on multimedia construction capitalise on the benefits of the ISDP type of environment without the external motivation of a target group? Is multimedia authoring software effective simply as a cognitive tool?

### Teaching With Interactive Multimedia Construction Tools

Jonassen and Reeves (1996, p699) review research findings on cognitive tools and list the principles which serve as the foundation for such research. Cognitive tools:

- will have their greatest effect when they are applied within constructivist learning environments.
- empower learners to design their own representations of knowledge rather than absorbing knowledge representations preconceived by others.
- can be used to support the deep reflective thinking that is necessary for meaningful learning.
- have two kinds of important cognitive effects as a form of cognitive technology: *with* the technology in terms of intellectual partnerships and *of* the technology in terms of cognitive residue that remains after the cognitive tools are used.
- enable mindful, challenging learning rather than the effortless learning promised but rarely realised by other instructional innovations
- should be used on tasks selected by learners, and guided by teachers and other resources
- should be used for tasks situated in realistic contexts and yield personally meaningful results for the learner

- do not contain preconceived intelligence in the sense that intelligent tutoring systems are claimed to do, but they do enable intellectual partnerships in the form of distributed cognitive processing.

When students are permitted to occupy the role of interactive multimedia producers with a focus on the knowledge construction process, they are publishing for personal viewing. All the information searching, discussion with peers, mistakes, re-makes, media production, screen construction and linking are vital elements of the process the students experience. Immediately they must take an active approach to the appraisal, accumulation and generation of relevant resources.

Low level authoring tools, such as HyperStudio®, which place fewer demands on cognitive load than high level production tools, permit the students to rapidly construct a series of screens. These may undergo many revisions before the underlying structure and interrelationships among concepts are perceived. By externalising this evolving body of knowledge in multimedia format, the constructors can brainstorm, reflect, revise and re-construct what they know at any stage in the overall process.

This building process is not initially driven by principles of interface design, or need to perform for others, though students usually develop their own interface style. This process is self-motivated, driven by the students' desire to clearly express a concept, usually one screen at a time. They have a chance to play with combinations of relevant self-generated or personally selected media, to express ideas in different ways. As concepts are described with increased depth of understanding, clearer interrelationships and overarching concepts may emerge. Eventually the program may develop a coherent architecture with clear navigation. The constructors generate their own feedback each time they review and reflect upon the structure and content of their multimedia knowledge base.

This approach does not yield a "finished product". Frequently at the end of a period of construction, students are able to clearly and simply explain how they would publish their ideas in a sophisticated design, if they had a production team on hand. The implementation of this design may no longer be the point— the students are ready to move on.

A teacher watching the evolution of ideas is quickly able to identify what the students understand well, and what aspects have yet to be clarified. The more clearly a student understands something, the more simply they can explain it or visually demonstrate understanding. Great detail and complexity through "cut and paste" exercises do not necessarily indicate student comprehension of the detail.

The knowledge construction process for an individual learner can be ongoing. Document editing, linking and synthesis may continue. As the body of information and its associated structure lose coherence for the constructor, they must begin the process of re-structuring to incorporate new information. The inner processes of assimilation and accommodation are externalised.

Interactive multimedia construction to facilitate the learning process can be an individual or group activity. Several features of the group process distinguish it from that experienced by the individual:

- the need for group skills such as collaboration and cooperation
- an increased demand for both hardware and software to meet the increased capacity of a group to generate and construct resources
- numerous opportunities to discuss material, and to learn through teaching other group members
- valuable feedback from group members
- development of interpersonal skills

Interactive multimedia construction offers the learner many advantages. It is an active process which is personally meaningful and promotes deep processing of knowledge. It facilitates the development of a wide range of associated social, technical and problem-solving skills, permits knowledge representation in a range of media forms, and allows the learner to engage in a long term process. Many skills may be anchored and integrated within one context prior to their transfer to other situations. Teachers have the opportunity to observe the thinking processes of learners, rather than checklist outcomes which may lack a meaningful context.

Moderate levels of hardware and software resources are required to support the learner as constructor, and considerable flexibility in timetabling can unsettle those teachers who prefer set management procedures. Without the personal experience of the knowledge construction process, many teachers would not anticipate the needs of the learners, or be able to maximise their support of learners.

*Reflections on Class G&T* : The G&T class was focused on the process of student construction of interactive multimedia as a means to facilitate learning. Primary school aged children (9-11 years) were experiencing the process of knowledge construction using an array of media— they had the opportunity to be knowledge designers. This class differed from the two stages of the EDUM class, which were focused on skill development for interactive multimedia production— a product focus. The differences emerged across resources, processes and process outcomes. *Table 6.6* below presents the unique resource requirements of the G&T class:

| *Resources* | *G&T Class—Creative Extension With Multimedia Construction* |
|---|---|
| *People* | A team of teachers/parents was required to support resource generation, not digitising. |
| *Machines* | Machines severely limited project construction in terms of limited RAM and hard disk space. Video was actively used to generate personally meaningful resources. |
| *Media* | Media were student-generated or selected, but not digitised by students. |
| *Teacher Tools* | Print material was good for organisation away from the computers, and for resource management and group planning. "Disposable" teacher-generated software was excellent as a reflective device, and the cognitive tool *Themes* was handy for resource viewing and idea brainstorming. |

*Table 6.6: Resource Requirements for the G&T Class*

Several features contrast markedly with the resource requirements of the EDUM classes listed in *Table 6.3 (p211):*

- More teachers and assistants were required in the G&T class. Where peers took over this role in the EDUM classes, adult attendance was important in the G&T class. Although this was largely due to the age of students, the varied input of a range of helpers was vital to retain creative diversity within media production.
- Computers limited G&T student project work in the closing stages, due to insufficient RAM, inadequate hard disk space on some machines, and lack of portability of student work which exceeded high density floppy disk capacity. This was not surprising given the comparison between a well-equipped primary school computer laboratory, and a fully-equipped interactive multimedia laboratory geared to teach interactive multimedia production.
- The video recorder was used in the G&T class to generate student resources. In the EDUM classes it was used by students to monitor the production process or by the teacher as a teacher tool.

- G&T students generated media, but were not responsible for developing skills in the digitising process, unless it was a natural consequence of software use (SoundEdit Pro® or HyperStudio®). The researcher scanned images, digitised video and digitised audio when it was recorded with the tape recorder.
- The nature of teacher tools was different. In the G&T class, print material was geared to provide an activity framework away from the computer, not provide software support. Teacher generation of "disposable software" was vital to the process of reflecting student work, as a focus for discussion and sharing of construction strategies. The cognitive tool *Themes* was important in the management of project work. Firstly it allowed students to brainstorm initial ideas, and secondly it allowed them to manage their ever increasing bank of group resources. These resources were collected across a wide scope. In contrast, students in the EDUM classes did not gather this range of resources. They targeted specific material for their multimedia product. Teacher-generated performance support tools in EDUM 212 were not generic, like *Themes*, but specific to the individual needs of one or several projects.

Group knowledge construction with HyperStudio® led the G&T students through some unique processes, as indicated below in *Table 6.7:*

| Course | Unique Processes |
|---|---|
| G&T<br><br>Creative Extension Work with Multimedia Construction | • student-driven development of skills<br>• selection of groups based on common interests<br>• initial brainstorming of group project ideas using *Themes*<br>• reflective demonstrations and discussions preceding classes<br>• emphasis on resource research, appraisal and production<br>• flexible group arrangements within and across groups<br>• concurrent activities pursued alongside project work<br>• separation of media production and computer construction times<br>• flexible multimedia construction with a process focus<br>• closed "Show and Tell" for students and teachers only |

*Table 6.7: Unique Processes in the G&T Class*

These processes contrasted with those processes experienced in either stage of the EDUM classes listed in *Table 6.4 (p 213)*:

- G&T students developed skills on a needs basis. They were not systematically skilled in aspects of HyperStudio® construction or resource digitising
- G&T students selected groups on the basis of common interests. This meant there was considerable variation in group size, and ratio of males:females. Paired work in EDUM 221 was on the basis of friendship, perceived skill or proximity in the HyperStudio® task, and for the group project, it was on the basis of technical skills and necessity. No common interests necessarily bound the EDUM students with paired or group work.
- G&T students brainstormed group project ideas first, using *Themes*. This enabled them to expand the possible range of material they wished to cover, before they began to focus on screen construction. With many ideas in mind, students then headed to the library or were able to generate resource material themselves. There was no evidence of this initial divergent phase in individual project work in EDUM 221, or in the major projects of EDUM 212. Students tended to focus in very quickly on what they wanted to do.
- G&T students discussed each others' work in the reflective sessions at the beginning of most classes. Since they were exploring various combinations of media in a flexible manner, the students were open to strategy sharing before classes. The EDUM students were focused on the development of their own product, and saw little benefit in the sharing of ideas which were not directly related to their project.
- G&T students focused on research, appraisal and production of resources. They gathered widely, but were then very specific in the selection of media elements for a particular screen construction. When no resources were available, students were happy to produce their own. Resources for the EDUM projects were seldom generated by the students. They were digitised from other sources of a more commercial standard.
- G&T students formed groups in a flexible manner in response to the needs of the current situation. On several occasions the class had high levels of absenteeism. This meant normal groups were highly disrupted. Students were not bothered at all by this, and were quite happy to either team up with others, work on quietly by themselves, or intermittently wander around to observe, assist, or give feedback to others. Such flexibility was not a feature of paired or group work in the EDUM classes, where a product focus meant work was often specifically delegated. Absenteeism caused far greater problems for the rest of the group.

- G&T students focused on either media production, or computer construction—there was a distinction in the class between these two activities, which permitted students to immerse themselves in the production of a media element as a meaningful activity in itself, if they wished. For some students, video production was possibly the highlight of the whole process. Other students had no need for video production, so they used this time to plan other work. Students in the EDUM classes focused on digitising commercial quality video or material which was not copyright free. They chose not to involve themselves in video production unless they had no alternative.

As a result of the resource requirements and processes undertaken within the G&T class, a range of process outcomes were unique to this class. These are presented below in *Table 6.8:*

| *Course* | *Unique Process Outcomes* |
|---|---|
| *G&T*<br><br>Creative Extension Work with Multimedia Construction | • students experienced support from both peers and a team of teachers who were able to complement each other<br>• students determined the nature and pace of skill development with computers<br>• students were less concerned with how to use HyperStudio® than with what they could do with it<br>• students visited the computer laboratory and used the computers for an average of one hour every two weeks (total hours ranging from 9-15 hours over the 27 weeks of classes)<br>• students experienced extended involvement in a topic they were interested in through flexible group work<br>• students experimented with audio and video production only if it was appropriate to their project<br>• students were unable to work on their group projects in the computer laboratory in the last few weeks due to RAM shortage<br>• students focused more on content research, resource production and individual screen design than overall program structure<br>• students exhibited great cognitive flexibility— when one idea didn't work they were willing to drop it and try another |

*Table 6.8: Unique Process Outcomes in the G&T Class*

These process outcomes can be contrasted with those experienced in the two stages of the EDUM class, presented in *Table 6.5 (p 216)*. Though some are very situation specific, such as the memory shortage on machines, most reflect the fundamental G&T class orientation towards *process*, rather than product:

- knowledge of software tools was secondary to exploratory construction. Students did not learn *about* HyperStudio®, they learnt *with* HyperStudio®.
- students spent a maximum of between five and nine hours at the computer constructing their projects over a 17 week time period (see *Table 5.3 on p 173*). This is in sharp contrast with the average of 3 hours per week the EDUM students spent in the interactive multimedia laboratory. The computer was a decentred participant for the G&T students.
- group work was flexible and collaborative, rather than cooperative. Collaboration was very strong across groups. This was facilitated by the reflective sessions at the beginning of classes, and the flexibility of class arrangements.
- audio and video production work was optional for the group project. This was in sharp contrast with the individual HyperCard® project in EDUM 221, but parallel to the major individual projects in EDUM 212, where project themes determined the nature of resources.
- the research and resource generation processes were of equal weighting with the construction process. G&T students focused more on content than the nature of their final product.
- cognitive flexibility was notable in the way students were very quick to replace one idea with another, given a change of circumstance such as partner or production technique. They did not concern themselves when one path could not be followed for reasons outside their control. The generation of alternatives was considered a challenge.

*What others have found:* In the Instructional Software Design Project (ISDP), Harel (1991b) monitored children's production work very closely, conducted interviews with them and exchanged ideas when she felt the time was right to extend thoughts with discussion. The class was student-centred in a similar manner to the G&T class. Harel adopted the role of a researcher, alongside the class teacher, though she did run some instruction sessions. The students in Harel's study were a similar age to the G&T students. Accompanying these similarities between the studies were a number of key differences:

- G&T students experienced the computer as a "decentred participant". More emphasis was placed on work *away* from the computer, such as audiovisual production, library research, and planning. When computers were used it was not unusual for students to work in pairs or small groups. In the ISDP, students wrote notes before and after an hour long individual computer session each day.

- G&T students received no instruction on software design models, whereas Harel specifically discussed product design with her students.
- G&T students were allowed to select their own project themes. ISDP students were given the topic for their product development— fractions.
- G&T students used computers in different ways— for writing the Newsletter, doing Science Reports, and for Computer Newsday. ISDP students did not experience this variety of application software.
- G&T students output information in multiple formats and combinations— text, audio, video, and a range of graphics (hand drawn, selected for scanning, modified scans, computer generated graphics). ISDP students used Logowriter, and were able to generate graphics.
- G&T students were not focused at all on a programming language. Although it was integrated in a design framework, one of the express aims of ISDP was for the children to become more proficient with programming in Logo.

Jonassen and Reeves (1996) analysed the use of computer programming languages as a cognitive tool. They supported Harel's "exemplary approach to the integration of learning programming into a design and problem-solving environment", but reported that the results of studies on learning to program were inconsistent and generally disappointing. They stated:

> *"The primary conclusion of programming research is that the cognitive overhead (the amount of mental effort required to use programming languages) mitigates the ability of the learner to use computer programming as an easy and effective means for solving problems or representing what they know, which is the goal of cognitive tools in the first place....There is little doubt, however, that computer programming is among the most flexible and powerful of the cognitive tools for those who are skilled programmers. It is the requirement of these complex skills that calls into question the utility of computer programming as a cognitive tool." (Jonassen and Reeves, 1996, p 705)*

The low cognitive overhead of the multimedia construction tool HyperStudio® permitted the G&T students to construct, modify and re-design their knowledge representations with relative ease. The breadth of social, technical and communication skills the G&T students acquired, and the knowledge and cognitive flexibility they exhibited, validated the *process* focus with simple multimedia construction tools as an alternative to the more complex and costly *product* focus pursued in the EDUM classes and Harel's ISDP. For Harel's group, teaching occurred through the software designed by the fourth grade students for their third grade peers. For the G&T students, teaching occurred within the group team as part of content negotiation— students taught themselves and each other. They were able to express multiple representations as well as multiple modes of representation. Content orchestration at the screen level was initially more important than an integrated architecture. The aim was to discover structure in content via the exploration of multiple representations. Diversity was applauded and editing expected.

In a modest way the G&T class approached the new discourse described by Hooper Woolsey (1994):

> *"Yet, if one is truly to support a new kind of thinking— a new style of discourse; the kinds of things enabled by these new technologies and design methodologies— one must provide schooling for people in the fundamentals. One must provide a 'visual thinking' culture which encourages the use of visuals in the representation of ideas, which appreciates one's ability to see-and-draw and imagine-and-draw, as well as one's ability to read, write and do arithmetic. It is in the widespread development of such capabilities that one can provide the supportive milieu in which multimedia will flourish and become a way of life, as well as a new publication medium." (Hooper Woolsey, 1994, p96)*

Any publication medium spawns a range of genre— which are socially grounded patterns of communication. Products for publication are usually the outcome of an iterative editing process. One possible assumption is that greater skill in the editing process will lead to a more consistent, if not polished, final product. Process writing represents conscious focus on editing skills and the recursive nature of editing as a means to a better written product.

Emphasis on process versus product in multimedia "publishing" is alluded to by a number of researchers in different ways. Harel (1991b) refers to the ISDP environment as one which encourages "design for learning" or "learners as designers". Harel specifically emphasises the "product design component". Jonassen and Reeves (1996) distinguish between "designers as learners" and "learners as designers"— but their latter term does not equate with Harel's meaning. The distinction *they* make captures the essential difference between Model B and Model C, described in this chapter. For Jonassen and Reeves, "designers as learners " supports model B— the product focus, and blends with Harel's reflections on what she learnt as a designer:

> *"Ironically, the people who seem to learn the most from systematic instructional design of instructional material are the designers themselves.*
>
> *... Following the old adage that the surest way to learn about subject matter is to have to teach it, the process of designing and producing instructional material as performed by designers of educational communications enables instructional designers to understand content much more deeply than the students whose thinking will be constrained and controlled by the very materials they are developing. It follows that empowering learners to design and produce their own knowledge representations and educational communications is a powerful learning experience." (Jonassen and Reeves, 1996, p 696)*

Once they were able to reduce the cognitive overhead of digitising skills and HyperTalk® programming, students in the second EDUM class, EDUM 212, were able to focus more on content, for the express purpose of building a software program to teach or communicate with others. The skilling component was time and labour intensive, primarily due to the cognitive overhead of programming.

In contrast, "learners as designers" captures the essence of the G&T class in Model C— the process focus:

> *"Some of the best thinking results when students try to represent what they know. Representing knowledge as a mindful task can be enabled by cognitive tools such as hypermedia construction software or electronic spreadsheets. Such cognitive tools require students to think in meaningful ways to use the application's capabilities and features to represent what they know." (Jonassen and Reeves, 1996, p 696)*

As the motivation, engagement and range of process outcomes for students in the G&T class show, the task does not have to emphasise product development. With simple but powerful multimedia construction tools such as HyperStudio®, the reduced cognitive overhead of the construction process allows students to concentrate on content rather than on use of the tools. Self-regulated learners are able to set their own goals and tasks, provide their own feedback, and are the best judges of when they have reached or need to readjust those goals. The standards of achievement which the G&T students expected of themselves were higher than any teacher would realistically have estimated.

### ***Learning With Interactive Multimedia Construction Tools***

*Theoretical Perspectives:* Turkle and Papert (1991) aim to identify what they call "epistemological pluralism"— the existence of both "hard" and "soft" approaches to thinking:

> *"which serve as ideal types, theoretical prisms through which we see simplified projections of more complex realities.*
>
> *...Soft is a good word for a flexible and non-hierarchical style, open to the experience of a close connection with the object of study. Using it goes along with insisting on negotiation, relationship, and attachment as cognitive virtues. Our goal is the revaluation of traditionally denigrated categories. We do not argue that valuable thinking is not soft; we explore ways in which soft is a valid approach for men as well as women, in science as well as the arts." (Turkle and Papert, 1991, p166)*

The hard and soft styles are reflected in the act of computer programming. The hard Harvard programming style works with a rule-driven system which can be mastered in a top-down, divide and conquer way:

> *"...the 'right way' to solve a programming problem is to dissect it into separate parts and design a set of modular solutions that will fit the parts into an intended whole." (Turkle and Papert, 1991, p169)*

The soft style of the bricoleur programmer prefers negotiation and rearrangement of the material:

> *"The bricoleur resembles the painter who stands back between brushstrokes, looks at the canvas, and only after this contemplation, decides what to do next. Bricoleurs use a mastery of associations and interactions. For planners, mistakes are missteps; bricoleurs use a navigation of mid course corrections. For planners, a program is an instrument for premeditated control; bricoleurs have goals but set out to realise them in the spirit of collaborative venture with the machine." (Turkle and Papert, 1991, p169)*

The difference between the planners and bricoleurs is not in the product, but the process of creating it. For the bricoleur, each step is a small modification of a working program, which is gradually sculpted. At any stage, however, the program is functional. For the researcher, that functional program began as *PhD Diary*, and ended up *The Garden*.

*Researcher Reflections :* From the day the *PhD Diary* was constructed, February 19, 1992, the researcher experienced the benefits of learning with multimedia construction tools. The following account documents growth in the researcher's understanding of data structures— an understanding which can be directly attributed to the external construction and representation of data. Multimedia construction tools enabled this process to occur.

The researcher entered the current field of research with a thinking style moulded by eight years of "training" in clinical diagnosis. The diagnostic process viewed an animal in a global or holistic sense. Details about the status of the animal were determined by measuring as many factors/system indicators as possible. This data profile only gave an instantaneous view— it did not reveal much about the ongoing physiological status of the animal. Such information required the accumulation of multiple readings to determine the linear changes over time within each factor, and the changes in the non-linear interactions among factors. Patterns of factors which indicated a certain disease emerged on the basis of probabilities.

The field of education technology posed a considerable challenge to the researcher, since the key factors in this complex domain were unknown. The researcher's response was to apply the same principles of clinical diagnosis to this field— take multiple readings over an extended period of time, in order to reflectively identify the key factors, and develop an understanding of the interrelationships among these factors.

The construction of *PhD Diary* at the beginning of 1992 was the first step in this process. The electronic nature of sequential notes permitted a free flow of ideas— editing, refining, clustering and logical structuring could occur at any time in the future through simple cut and paste actions. No situations were ignored, since there was always the possibility that a new "clinical condition" was under observation.

Programming for the project *Investigating Lake Iluka* in 1992-1993 expanded the researcher's awareness of patterns or structures within data. As programming skills developed, the researcher was able to begin designing software tools such as *Themes*. Here the emphasis was on non-linear brainstorming of ideas to answer user-generated questions. As a range of uses for this tool were identified, the researcher realised it would not be appropriate for class work, as there was no representation of a time frame. The time-based linear aspects of the diary and the non-linear aspects of *Themes* eventually merged into a common data structure— the Garden Diary, once diary themes were identified in mid-1994.

These themes were patterns of association which emerged from the diary in a grounded fashion— they became the key factors in the study. The six themes existed as three complementary associations:

- literature/theory informed the classes and the experience of the classes illuminated different aspects of the literature on second reading
- researcher construction of tools balanced project work. The programming skills developed with project work were necessary for tool construction. This illuminated the distinction between the process focus of tool development or use, and the product focus of project work.
- The reflective emphasis of the diary permitted the researcher to develop metacognitive skills of planning, self-monitoring, data organisation and management, and self-evaluation. The multimedia presentations required at various points in time prompted the external representation of understanding to a specific target audience.

Once the key factors in the researcher's experience with education technology were clear, the use of the garden/gardener metaphor integrated them in a meaningful global structure. The "big picture" could then be described in a logical fashion in thesis format. The parallel development of the thesis and CD were complementary processes— *The Garden* structures emerged through bottom-up processing of data and the thesis chapters developed through top-down organisation of key elements in a logical sequence.

The development of *The Garden* matched the description of the bricoleur programmer given by Turkle and Papert:

> *"Bricoleurs are like writers who don't use an outline but start with one idea, associate to another, and find a connection with a third. In the end, an essay 'grown' through negotiation and association is not necessarily any less elegant or easy to read than one filled in from an outline, just as the final program produced by a bricoleur can be as elegant and organized as one written with the top-down approach." (Turkle and Papert, 1991, p172)*

The concept of epistemological pluralism calls for acceptance of the concrete thinking paradigm, and respect for multiple thinking styles rather than stratification into hierarchically valued stages. Papert challenges the Piagetian progression from concrete to abstract. Wilensky (1991) supports this on the basis of a redefined notion of 'concrete':

*"The more connections we make between an object and other objects, the more concrete it becomes for us. The richer the set of representations of the object, the more ways we have of interacting with it, the more concrete it is for us. Concreteness, then, is that property which measures the degree of our relatedness to the object, (the richness of our representations, interactions, connections with the object), how close we are to it, or, if you will, the quality of our relationship with the object.*

*Once we see this, it is not difficult to go further and see that any object/concept can become concrete for someone. The pivotal point on which the determination of concreteness turns is not some intensive examination of the object, but rather an examination of the modes of interaction and the models which the person uses to understand the object. (Wilensky, 1991, p198)*

This notion of concrete does not restrict children's thinking to a smaller "concrete" domain— but broadens it to include the "whole panorama of human intellectual endeavour." Wilensky (1991) translates this definition into classroom practice. Children should be exposed to multiple representations, and should be given opportunities to interact with all of them and to make their own connections between them. Rather than move from concrete to abstract, Wilensky suggests we in fact move from abstract to concrete as we relate to an object. The construction of an external representation of that relationship is important:

*"When people construct objects in the world external to them, they are forced to make explicit decisions about how to connect different pieces of their knowledge. How does one representation fit with another? Which pieces of knowledge are the most basic? Which are important enough to incorporate into the construction, and which can be safely left out? Which really matter to them and which don't engage them at all? The constuctionist paradigm, by encouraging the externalization of knowledge, promotes seeing it as a distinct other with which we can come into a meaningful relationship." (Wilensky, 1991, p202)*

For the researcher, the diary component of *The Garden* was essential to support the ongoing process of reflection, which stimulated both multimedia construction and thesis writing. Without this long term record of daily events, *The Garden* would not have taken on the global proportion it did. As Hooper Woolsey (1994) notes:

*"It is an old fashioned and rather inexpensive alternative, but simply spending some time noticing what is going on, reflecting upon it, and not doing anything is, typically, a critical element in learning. This reflection - some of it being the*

*metacognition so widely discussed today - becomes the glue that takes advantage of the experiences we can provide. A compelling goal for multimedia designers, then, is to find ways to combine action and reflection in an effective learning cycle, to combine user-initiated actions and system-encouraged reflection in new materials." (Hooper Woolsey, 1994, p93)*

The new materials referred to by Hooper Woolsey are likely to be more sophisticated, powerful, or flexible thinking tools— yet to be designed. As learners become more literate in multimedia discourse, designers will be able to determine the best tools to support a range of varied data structures and thinking processes across an array of disciplines. Undoubtedly these tools will need to acknowledge the epistemological pluralism of bricoleurs and planners, if they are to capitalise on the multimedia capabilities of computers, and cater to the broadest range of learners.

## 6.5 Comparison of Models

From the teacher's perspective, it would be difficult for any teacher not familiar with interactive multimedia to begin teaching anywhere but within the framework of Model A— Using Interactive Multimedia Software. Without the complex array of conceptual knowledge, technical skills and creative talents required to teach production, or experience with the free thinking and flexible nature of construction to support students in that process, teachers would not be well enough prepared to support Model B or Model C. The assumption has been made here that the teacher has an ample supply of computers capable of basic multimedia production and software use.

From the learner's perspective, they can begin in any model, quite independently. It is not necessary to have prior experience with interactive multimedia products to learn production skills or use multimedia construction tools. As learners become more fluent in software design, and begin to develop their own interface style, then learning activities for models A-C are complementary. Better production skills improve resource quality; use of other software provides ideas and a source of additional structures and strategies for accessing information; constructing information landscapes forces the constructor to analyse relationships between content structure and functionality. As constructors create hypermedia landscapes they are freed from the restriction of linear thought. They can begin to think about how others may wish to access the material, how the nature of that access may depend on the reason for access, and how important flexible access might be for re-use of material. They learn to design an evolving landscape.

For the researcher, the process of learning to use *any* program (model A) intuitively increases awareness of design features. The process of multimedia production (model B) develops a sense of the relationship between content and its structure, and clarifies current understanding of an issue which must be communicated to others as a product. The process of multimedia construction (model C), in a global sense, maintains an evolving personal information system, and facilitates the deeper process of lifelong learning. *The Garden* is a stage in a continuous construction process. The integrative metaphor may change in the future, in keeping with work requirements, but the underlying metacognitive processes of data management and reflection have become automated and efficient, within the scope of the current thinking tools. As these foundation processes are refined, the researcher is able to generate better products more efficiently.

Within a constructivist information technology classroom, the available hardware and software which determine the dominant model of computer use present half the equation for successful learning. The other half rests with the interpersonal, intrapersonal, cognitive and metacognitive skills of the teacher and students. These can be observed functionally as a series of roles which the teacher and learner can adopt.

## 6.6 Roles of the Teacher in a Constructivist IT Classroom

The constructivist teacher in a classroom which has access to multimedia-capable computers occupies a role which oscillates among reflector, facilitator, organiser, planner, and strategist. Whatever the range of skills they possess with interactive multimedia production, the following tasks are common across models A (teaching/learning using IMM software), B (teaching/learning about IMM production) and C (teaching/learning through use of IMM construction tools).

*Facilitate Process* : The teacher, through personal experience, needs to understand the process the learner is going through. They need to have experienced a similar process. Any teacher who is teaching using IMM software needs to sit and use the software with the students, to appreciate the nature of the tasks they have set. Any teacher who is teaching about production needs the production skills to do so, or a range of excellent technical support staff who are able to demonstrate production skills. To ensure that an integrated knowledge of production skills is maintained, a teacher of multimedia production will benefit from active involvement in a current IMM project. Experience helps them to develop a wide range of strategies for production techniques. A teacher who is teaching through use of IMM construction tools needs to experience the construction process and deal with resource management, limited storage space, selection of appropriate media and re-construction of an information system as ideas change.

Teachers who have experienced the process they are asking their students to engage in are able to offer support through the fruits of their reflections on their own experiences, which provide them with some baseline strategies. They are able to recognise patterns, foresee some of the problems, discuss issues before they get out of hand, and assist the overall process, whether it is use of software, IMM production, or IMM construction.

*Design Tasks or Tools* : The constructivist teacher is able to use the technology in various ways, according to their experience and level of expertise. Creativity resides in the design of the task, and is not dependent upon programming or sophisticated production skills. Tasks can be designed for use of existing software. Software product development can be initiated to develop multimedia literacy and promote cooperative group cohesion. Individual or group construction of information systems can be supported for the development and maintenance by students of individual portfolios or collaborative class resource collections.

Teachers have access to a range of applications or cognitive tools, and it is up to them to make the decision to teach *with* the tools rather than *about* them. They can permit students to design authentic tasks to use the software in meaningful ways. If teachers are competent programmers and designers, they can create their own software tools for the classroom— either as reflective "disposable software", or more reusable cognitive tools such as *Themes*.

*Organise Resources* : The open nature of tasks will generally focus attention on the organisation of resources. Though print material is difficult to organise, electronic resources require as much skill to manage. They may take up less physical space but the mental models required to manage these resources and the time required to ensure data is not lost is quite considerable. Students need to be taught these skills, but the teacher should serve a backup role to avoid unnecessary disasters.

*Provide Metacognitive Support* : Through personal experience and understanding of a process from their own perspective, the teacher builds up an extensive repertoire of production, construction and communication strategies. To this collection they are able to add the vicarious experiences of their students. It is the teacher's responsibility to model and initiate the sharing of strategies, to assist students in the development of sound metacognitive skills. These provide the foundation for long term engagement in ongoing tasks.

## 6.7 Roles of the Student in a Constructivist IT Classroom

Within a constructivist information technology classroom, the students need to take an active role in learning. They need to question, delve, construct and discuss issues.

*Produce IMM Resources :* Students need to generate their own resources as well as actively collect them. The range of resource modes available— text, audio, video and animation, provide the flexibility to initially involve learners in their most comfortable mode of expression for a particular task. As understanding and creativity develop, alternate modes of representation can be added. Since learners generate the context, they are responsible for conveying that context to their peers. Misinterpretations lead learners to explore multiple perspectives, and develop more nuanced judgement.

*Organise Resources :* The resources which students generate or collect should be their responsibility. They need to learn how to name and organise files, deal with issues of version control, and keep some record of data for future access. Resource management involves the development of mental models. Students should develop their own means to represent these models.

*Share Strategies :* Strategy sharing may be initiated by the teacher, but students need to follow suit and share their strategies, which are equally valid. In a supportive climate, they need to express their methods of researching, planning, production, organisation, resource management and group communication. Group work involves additional strategies simply to maintain the viability of group morale, provide positive feedback and ensure effective process outcomes. Strategy sharing may occur on an organised basis, led by the teacher or group leader, but is often more effective when it is spontaneous and supplied "just-in-time".

*Work Collaboratively and Cooperatively :* Group work means the students have to learn the social skills to handle shared responsibility. They need to overcome the hurdles of receiving constructive criticism, having to re-do work to suit the needs of the group, having to do something which is not their natural choice, and having to fit in with the timing of others. The emphasis on social skills is high.

Collectively, the reciprocal roles of teacher and student in a constructivist IT classroom are at various times active, reflective, individual, collaborative, cooperative, creative, expressive and most importantly flexible. The typical classroom model discussed in chapter two did not cater well for a teacher with a constructivist philosophy. The degree of flexibility which exists within a constructivist IT classroom is even less compatible with the rigid constraints of a fixed curriculum and standardised tests.

It is now time to return to the low power objective, and view the study from a global perspective. The final chapter re-visits the goals of the study, identifies the key findings and discusses the implications of these findings for future developments in this field.

# *Chapter Seven - Conclusions and Implications*

## *Introduction*

This study simultaneously responds to two needs in Education. One of these needs— the enhancement of learners' problem-solving skills and higher-order thinking, was a driving force behind the research. The other— a more creative approach to bridge the perceived gulf between art and science, was fortuitously satisfied as a bi-product of the study.

Given current access to the World Wide Web, students no longer have to manually seek out vast quantities of information— they can tap a "global" reservoir of readily accessed electronic information to solve real world tasks. The emphasis which multimedia construction places on skills of information appraisal, selection and processing is timely. Computer-directed interactive multimedia construction offers learners of diverse learning styles the opportunity to collaborate, reason, reflect and communicate in the external construction of an evolving body of knowledge. This process, which Papert calls constructionism, may happen on an individual or collective basis and is equally appropriate for small (G&T class) or large tasks (*The Garden*).

The three key words which initially emerged as the theoretical underpinning of this study—metacognition, multimedia and constructivism— have remained strong allies through their translation into classroom practice. This has produced several key process outcomes, each of which validate the constructionist process of interactive multimedia production and construction as a means to promote deep, self-regulated learning and higher order thinking. Multimedia construction also has great potential as a qualitative research tool.

The infusion of this application of computers into the learning environment provides teachers with an exciting stimulus for personal and professional development alongside their students. At the same time it challenges software designers to develop cognitive tools appropriate to the thinking processes of a specific discipline, and products which allow learners to construct their understanding. Students are challenged to collaborate, communicate, and to develop metacognitive skills for self-regulated lifelong learning.

The key findings are now explored in some depth. The implications of these findings are discussed for teachers, software designers, students and those who are concerned with the general direction of education— the policy makers.

## 7.1 Key Findings of the Study

The goals of this study were to:

- identify the process outcomes of learning through construction of interactive multimedia from teacher, researcher, designer and student perspectives
- construct an integrating framework for these perspectives, and
- analyse the implications of these findings for learners

This was achieved through the recording of a detailed personal account which spanned the full study period. The study unfolded both chronologically and functionally in three key stages—literature review and development of multimedia production and construction skills, classroom experiences, and analysis and synthesis of findings in both text (thesis) and multimedia formats. Since each of these stages permitted the researcher to adopt a number of different roles, the following key findings of the study are drawn from all stages, not just the classroom experiences:

- Literature review and multimedia skill development identified constructivism as a key theoretical concept which linked multimedia and metacognition. Constructivist theory will be discussed from the perspectives of the classroom teacher, the software designer and the researcher.

- Classroom experiences identified Papert's notion of constructionism as the situated and tangible aspect of constructivism. Constructionism will also be discussed from three perspectives— the classroom teacher, the software designer and the researcher. This will draw on researcher reflections and findings from classroom experiences.

- Data analysis (literature and classroom experiences) and synthesis (text and multimedia formats) identified a general framework within which to explore the relationships between interactive multimedia and learning. This framework shows the impact on learning outcomes as the learner is moved from the potentially passive role of software user to the active role of interactive multimedia designer (production and construction).

The findings are now expressed as statements which are substantiated by the literature which has been reviewed (throughout all chapters) and the classroom findings.

## *1. Constructivism does not rest easily in the typical classroom.*

Throughout the thesis a variety of descriptions of constructivism have been presented—each one identifying the unique perspective of the particular author. The following description by Fosnot (1996) presents a recent view:

> *"Constructivism is a theory about knowledge and learning; it describes both what 'knowing' is and how one 'comes to know.' . . . the theory describes knowledge as temporary, developmental, non objective, internally constructed, and socially and culturally mediated. Learning from this perspective is viewed as a self-regulatory process of struggling with the conflict between existing personal models of the world and discrepant new insight, constructing new representations and models of reality as a human meaning- making venture with culturally developed tools and symbols, and further negotiating such meaning through cooperative social activity, discourse, and debate. (Fosnot, 1996, pix)*

In chapter two, the constructivist philosophy was discussed within the framework of the typical classroom, devoid of computer based interactive technologies. This is still the current framework for many teachers. Within this typical classroom it is extremely difficult for a teacher who supports the constructivist philosophy to maintain a sense of professional achievement when he/she is positioned between an overburden of curriculum objectives which demand that students know specific parcels of knowledge, and standardised tests which will hold him/her accountable for the amount of such knowledge the students can retain in the short term.

The current system, which is run according to rigid, content based objectives and fixed testing of those objectives, is aligned more with the objectivist view of knowledge as something which can be transmitted to a passive learner. All the learner must do is reproduce that knowledge structure. Though accepted as desirable attributes of the current system, there is little support for creative student expression, natural evolution of ideas, pursuit of individual goals, or teacher-community liaison to facilitate student experience of authentic activities. The school community as it exists represents a somewhat isolated and artificial environment which serves its own ends.

Fosnot (1996) relates constructivism to a very different classroom:

> *Although constructivism is not a theory of teaching, it suggests taking a radically different approach to instruction . . .a constructivist view of learning suggests an approach to teaching that gives learners the opportunity for concrete, contextually meaningful experience through which they can search for patterns,*

*raise their own questions, and construct their own models, concepts, and strategies. The classroom in this model is seen as a mini society, a community of learners engaged in activity, discourse, and reflection. ...teachers assume more of a facilitator's role and learners take on more ownership of the ideas. Indeed, autonomy, mutual reciprocity of social relations, and empowerment become the goals." (Fosnot, 1996, p. ix)*

Honebein (1996) presents a lengthier list of goals for constructivist learning environments, which should:

- provide experience with the knowledge construction process
- provide experience in and appreciation of multiple perspectives
- embed learning in realistic and relevant contexts
- encourage ownership and voice in the learning process
- embed learning in social experience
- encourage the use of multiple modes of representation
- encourage self-awareness of the knowledge construction process

For a teacher to actively embrace the constructivist philosophy, the type of goals suggested by Fosnot and Honebein need to be held throughout the school system—reflected across the curriculum, the administration and tertiary institutions. Society in general needs to support the flexibility and individuality of constructivism to permit teachers to freely engage in classroom practices which aim to achieve these goals. A systems thinking approach identifies limits to growth (Senge, 1992). Currently, for an increasing number of people, standardised tests reflect yesterday's dominant societal attitudes towards education, and today's major limit to growth in the adoption of the constructivist philosophy within the education system.

Tertiary institutions play a significant role in maintaining the dominance of standardised tests as an output measure of our secondary education system. They largely dictate the output requirements of secondary education to serve their own needs. Professional development is one major goal of tertiary education, and cognitive apprenticeship provides a situated, flexible method of gearing professionals to the changing needs of society. Standardised tests reflect little of a student's social maturity or practical skills, both of which are vital qualities in the development of most professionals. It is somewhat surprising, therefore, that tertiary institutions maintain their rigid stance on numbers which reflect only limited ways of knowing.

Anderson (1994) discusses three types of intelligence which university teaching aims to support—technical, critical and civic intelligence.

*" The development of technical intelligence in students is what is done best in universities these days and for which they have a deservedly high reputation.*

*... If technical intelligence is about means, critical intelligence is about ends. Technical intelligence is about how to get from A to B; critical intelligence asks whether B was worth getting to. ... Critical intelligence does not always rest easily with technical intelligence in the preparation of professionals—professional practice calls for certainty, not uncertainty; for one true way, not alternative ways of looking at things."*

*"Civic intelligence requires that practitioners should have a good appreciation of the society in which they practice their trade—its history, literature, politics and sociology—and that there should be a sense of public identity and responsibility." (Anderson, 1994, pp111-112)*

The need to embrace technical, civic and critical intelligence within professional preparation means a tertiary institution should link technical theory with authentic professional practice to foster the growth of civic intelligence. It should also present professional practice in sufficient complexity to demonstrate the need for critical intelligence— the intelligence which is required to *question* technical and social practice with sensitivity.

Curriculum development to support the constructivist philosophy is recursive and iterative, which ensures that it has the potential to change quite readily according to the changing needs of society. In a constructivist curriculum, the focus switches from expectations of teacher driven external motivation to student centred goals and self-regulation. The demands of work and social change necessitate the learner's acceptance of a lifelong approach to learning, which can satisfy practical, academic and personal needs.

For tertiary institutions, this throws into question the period of relevance of an undergraduate qualification. It suggests an increased demand for ongoing professional development via postgraduate study or other forms of continuing education. Undergraduate and postgraduate courses become two points on an education continuum, providing each other with supportive environments for professional development. Active professionals in postgraduate studies are ideal role models for current socially mediated professional practice, while undergraduate students are the role models for the application of the latest technical developments. Anchoring more students across both tertiary institutions and professional practices fosters a two-way relationship of cognitive apprenticeship.

The concept of evaluation is broad from a constructivist perspective— it allows for multiple representations of achievement according to both student and teacher nominated criteria. Goal driven learners can state their goals and know better than anyone else when these are achieved.

The evaluation criteria for constructivism suggested by Jonassen (1991b) in chapter two seem at first glance to apply more to advanced knowledge acquisition in ill-structured domains. On closer examination, they are equally valid in a primary or secondary school which adopts an integrated thematic approach, student identification of authentic and personally meaningful activities, and flexible evaluation methods which support individual differences and value the presentation of an argument.

### *2. Constructivism provides a challenging basis for the design of educational software.*

Learning theory provides a rationale for the design of educational software, and has influenced the role of the educational software designer, as discussed in Chapter Three. The constructivist designer aims to produce software which supports learner construction of knowledge, and employs thinking tools geared to specific discipline or work related thinking processes. Many of the traditional systems models of the instructional design process no longer apply to the development of this style of software. The product is no longer content driven or restricted to specific learning outcomes. The learner is no longer regulated within an electronic framework determined by the software designer. The constructivist designer does not aim to control the acquisition of specific learning objectives (position A in *Figure 3.2,*). He/she acknowledges the social and situated aspect of learning, and collaborates with the teacher (position B in *Figure 3.2*) or designs thinking tools to support a particular process (position C in *Figure 3.2*).

Designers can collaborate with teachers and students in the construction of democratic information landscapes, which leave the learner free to explore, accept inbuilt challenges, or pose their own questions and determine their own cognitive needs. Learners can also use cognitive and metacognitive support tools created by the designer. An important aspect of this style of software is the vital role played by the teacher and peers. This is not stand alone software. The learner has to deal with the information landscape and its tools, many of which will stimulate cognitive processing in ways which are new to the learner. Cognitive apprenticeship and cognitive flexibility theory support the need for the richness and complexity of these landscapes, which must be crossed multiple ways and many times to develop an understanding of complex and ill-structured knowledge domains—a feature of professional expertise and problem-solving. Students need support throughout this lengthy and iterative process.

More recent developments in this style of software parallel the move from static information storage mechanisms such as CD ROM, to dynamic media storage on distant servers throughout the WWW. These may provide regularly updated information if Web sites are adequately maintained. Fixed media storage offers a slightly more constrained environment with inbuilt support, to introduce the learner to a more self-directed process. Learning strategies adopted on fixed media with inbuilt cognitive tools may well assist the learner to cope with the complete freedom of the WWW. Such freedom demands high levels of planning, monitoring and reflecting, to ensure the original goal is held in sight.

The constructivist designer can maximise learner control and self-regulation through the development of cognitive tools. Usually considered application software, or empty shells for the learner to fill, these programs permit the learner to direct their attention to such processes as information appraisal, selection, production, organisation, construction and presentation. Different tools may be used for various processes, and many variations on a tool may be used for the one process, depending upon the type of information or its intended use. Such tools challenge educational software designers to develop more sophisticated mechanisms to support thinking processes which now emphasise data organisation, annotation and structuring, more than gathering. This fosters a much deeper approach to learning.

### *3. Constructivism provides a sound framework for the research process.*

Constructivist curriculum design is a cyclical and repetitive process. A researcher who is permitted the freedom to work within a constructivist learning environment designs his/her own curriculum in a similar manner. One goal of that constructivist environment— self-awareness of the knowledge construction process (Honebein, 1996), was achieved by the researcher through reflection in the "Process" theme of the Gardener's Diary. As research strategies were identified, a cyclical pattern emerged. Forward planning usually initiated a cycle. One of the early and more lengthy cycles of the study is presented in *Table 7.1*:(on the following page)

The recurrence of many such cycles during the study permitted the researcher to respond to environmental changes in a flexible manner, and capitalise on research opportunities, such as the teaching experience of 1993, the interactive multimedia workshops, the G&T class study and several of the projects. Each new venture shifted structured knowledge domains—a feature of professional expertise and problem-solving. Students need support throughout this lengthy and iterative process.

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### *4. Constructionism in the classroom facilitates communication and fosters deeper understanding.*

According to Jonassen, Myers and McKillop (1996), the concept of constructionism developed by Papert argues:

> *"that constructivism is most readily manifested when learners become constructors and producers of personal products that can be shared with others. Although we believe that learners can construct meaningful personal representations without producing external, physical products, constructivist processes are more evident when students collaborate to produce and share representations of their understandings of the world.*
>
> *... Our belief is that producing hypermedia and multimedia products is among the most complete and engaging of the constructivist/constructionist activities." (Jonassen, Myers and McKillop, 1996, pp93-94)*

They justify this stance with Perkin's idea of knowledge as design, with the view of knowing as a process of negotiating sense, and with emphasis on the use of cognitive technologies to amplify and reorganise thinking.

In the EDUM and G&T classes, students used multimedia construction tools in one of two ways— either with a product focus on multimedia production (EDUM class), or with a process focus on knowledge construction (G&T class). For all these students, the production and construction of multimedia was engaging and highly motivating for a sustained period of several months, permitted students to express their creativity and individuality, promoted higher order thinking and cognitive flexibility, and demanded increased reflection and communication of strategies.

At various times in the construction process the learners may have been:

- starting with an a new idea (conceptualising)
- brainstorming with self/others (diverging)
- searching out a range of media (resourcing)
- experimenting with various combinations of media (juxtaposing, harmonising or complementing media elements at the screen level)
- experimenting with various knowledge structures (structuring the knowledge base in a particular pattern of interlinking screens)

When the learners began with a process focus (G&T class), their goal was to identify a knowledge structure which was personally meaningful. Through iterative construction with a simple tool (HyperStudio®), information was processed at a deep level from multiple perspectives, due to the nature of collaborative and cooperative group work. Once the meaningful knowledge structure was identified, it was quite simple for students to convey this to their peers as a multimedia "product"— whether this constituted one screen or a combination of screens.

The EDUM students did not have the luxury of such "play" with media elements using simple construction tools. They missed the groundwork of data exploration and processing, due to the cognitive load associated with the various production tools they had to master. EDUM students jumped straight into a product orientation as multimedia designers, and were required to learn some programming skills to achieve even simple results using HyperCard® as their authoring tool. They were denied access to many of the benefits of the rapid editing facilities which simple multimedia construction tools like HyperStudio® offer.

In many ways the EDUM students were forced in multimedia format to "write in the old style", focusing only on what the final product should look like. The G&T students were allowed to indulge the multimedia equivalent of the process approach to writing.

### 5. Constructionism should be a feature of educational software design and a basis for tool development.

The facility for the learner to use construction tools to select media elements within an information bank, then organise and construct their own knowledge representation, should be a feature of any educational software which aims to assist the learner in the deep processing and uniquely meaningful structuring and interpretation of the content. This applies whether the source of the information is a static (CD ROM) or dynamic (WWW) medium.

Two educational software packages which illustrate this concept on CD ROM have been developed by the Interactive Multimedia Learning Laboratory (IMMLL) in the Faculty of Education at the University of Wollongong. The first program— "Investigating Lake Iluka", provides the user with a notebook capable of storing text, and a range of exploratory tools to investigate and take measurements in four ecosystems. The notebook contents can be saved to disk and re-accessed with subsequent use of the software. The user can edit and complement the text document in whatever word processing program they wish.

The second program— "Exploring the Nardoo", develops the notebook concept to full multimedia capacity. The user is able to collect a range of media elements in their personal digital assistant (PDA)—text, images, audio and video. Media elements may have one or more forms of representation. For example, an image of an animal may be accompanied by a text description; video or audio snippets are accompanied by their text transcript. The user is able to gather media elements as they traverse the river temporally or geographically. What they collect in the notepad of their PDA can be transferred to an editing tablet to be re-structured and refined according to the specific publishing genre they choose. At present, the multimedia contents of the user's notepad are only available in a linear format, in accordance with the current dominance of text genre in schools.

Learners should be able to adjust and review the changes in their knowledge structure as they develop better understanding. Methods of knowledge structuring, and the media elements chosen by the learner to demonstrate understanding, are likely to be highly varied, considering the many ways individuals vary in their learning styles (Claxton and Murrell, 1987), and the fundamental differences observed by Turkle and Papert (1991) between the bricoleurs and the planners.

The development of software authoring tools to facilitate independent learner construction have reflected some of this variation in style and functionality. Jonassen, Myers and McKillop (1996) reviewed examples of hypermedia/multimedia as design. Various research groups designed their own tools to facilitate student construction as a learning exercise:

- *MediaText* was developed by the Highly Interactive Computing Environments (Hi-CE) Group at the University of Michigan. It is a multimedia composition tool which creates and generates multimedia. It contains a word processor, a media link device, and a range of media tools. Jonassen et al (1996) cited the work of Hays, Weingard, Guzdial, Jackson, Boyle and Soloway (1993).
- *HyperAuthor* was designed by Lehrer (Lehrer, 1993) to allow students to engage in HyperComposition:

  *"which involves transforming information into concept maps, segmenting information into nodes, linking the information segments by semantic relationships, and deciding how to represent ideas." (Jonassen, Myers and McKillop, 1996, p98)*
- The ACCESS Project (American Culture in Context: Enrichment for Secondary Schools), based around the work of Spoehr (Spoehr, 1994), initially presented students with information in a hypertext format. During the period between 1991 and 1994, the project orientation shifted to more active student involvement. The researchers developed a mouse-driven authoring tool palette to permit students to rapidly carry out authoring activities.

For the EDUM and G&T classes, the researcher did not need to develop an authoring tool such as *MediaText* or *HyperAuthor*, though "disposable software" and cognitive tools such as *Themes* were constructed or developed. During the nineties, software developers have become more attuned to the potential market for construction software. With tools which are simple and intuitive, yet very powerful in their information manipulation and transformation capabilities, learners are able to build their own information systems of varying capacities for various uses.

Students in the EDUM class used HyperCard® as their knowledge construction tool, with a focus on multimedia product development. The cognitive overhead or load of programming was too high for these students to gain the skills to arrive at the point of re-structuring their knowledge base within a one semester class. Planning for a product occurs largely on paper prior to screen construction, particularly when authoring skills are new. HyperCard® as a programming environment did not lend itself to the easy connection and manipulation of data structures provided in *HyperAuthor*. In addition, the students were motivated to produce multimedia by the need to generate an educational product for students of a self-specified age range. EDUM students were not free to explore an area of personal interest in a self-directed fashion. They were learning about multimedia production to put on a "teacher's hat".

Students in the G&T class study used HyperStudio® as their knowledge construction tool, and were permitted the freedom to be learners, and build according to their own interests and needs. They could work collaboratively and cooperatively, and were able to focus as much on media production as knowledge construction. The emphasis was moved from skill mastery to personally meaningful knowledge design. At present, as a construction tool, HyperStudio® provides a broad range of facilities to connect and edit media elements, but it does not support a range of overall data structures at the card level. Students can easily build a linear or hub structure. The storyboard facility, which captures a sequence of screen miniatures, gives students a sense of the linear flow of screens in a stack. However, there is no way that the student can generate an arrangement of links among these screens in a "top-down" fashion, and have those connections implemented automatically at the card level.

All these construction tools serve different needs, learning styles and levels or patterns of knowledge structuring. Some are *multimedia* composition tools which emphasise the combination of media elements in a simple linear or hub or hierarchical design. In the case of the hierarchy, students usually need to plan this design on paper then implement the screen connections, as few simple construction tools provide this sophisticated facility. Authoring tools limited mainly to linear structuring either foster the production of small presentations, or multiple entities which must be manually interconnected in more web-like arrangements.

Other tools focus on *hypermedia* environments, and support the clustering of ideas and multiple linkages among nodes of information. As identified by Spoehr in the ACCESS project (Spoehr, 1994), students who benefited most from the use of hypermedia systems were those who could visualise the conceptual structures within the information base. The ACCESS solution to this problem was to let the learners build their own system. As constructors they were forced to develop an information structure, and this process promoted a deeper orientation to learning.

The development of thinking tools to deal with various media elements in innovative and creative ways, and to offer the user a range of information structuring tools, is now a major challenge for educational software designers.

### *6. Constructionism was soundly supported by the research study as a process to acquire deep and evolving understanding.*

The researcher was able to utilise a range of methods to externalise, reflect, construct, analyse, synthesise, reflect again and re-construct understanding in this study. Individual discussions, social discourse, reflective recording, public presentations and product-driven projects were an integral part of this process. Each was an external construction of a different format.

The final product of this study— the thesis and the CD— THE GARDEN, represent complementary forms of expression. What they convey together is greater than the sum of the parts, and hopefully will communicate with a target audience both within and beyond the academic community. At a superficial level, THE GARDEN and this written thesis represent non-linear and linear versions of the study. Even though the "PhD Walk" within *The Garden* is a two dimensional image of the study under the low power objective, to the researcher each object in this garden scene is a node which represents a period of intense involvement in one particular activity or functional role— a period of the study under the high power objective. There is no hierarchy to dictate the order in which any garden object can be viewed— only the motivation to address needs and interests. The interrelationships among this web of nodes have been captured in the Gardener's Diary. That is where various combinations of the parallel themes converge on a day to day basis. Detailed information can be accessed with a few mouse clicks. The "PhD Walk" is the common point of access which ensures that each node is viewed within the full study context.

In real time, the process of thesis generation took a tortuous pathway through various garden objects in search of a logical structure. The resulting bird's eye view is quite simple. Chapter One has summarised the timeline aspect of the Gardener's Diary. Chapters Two and Three have delved deeply into the Theory Pool. Chapters Four and Five explored and analysed the EDUM Tree and the G&T Bed. Chapter Six integrated the researcher's experiences within the Toolshed and Project Birds with an analysis of the EDUM Tree, G&T Bed and Theory Pool. This chapter parallels the autumn leaves in *The Garden.* The findings presented here reflect the text-driven process of analysis and synthesis within this thesis. The leaves within *The Garden* reflect the personal, more emotional process outcomes of garden construction which are specific to the researcher.

While the thesis represents a set of ideas at one point in time, *The Garden* will continue to grow and evolve, providing a resource which can be repeatedly tapped in the future as a source of multiple products. The thesis is analogous to the central metaphor of Cognitive Flexibility Theory (Spiro and Jehng, 1990)— the "criss-crossed landscape". Spiro and Jehng cite and extend the work of Wittgenstein (1953), who, rather than oversimplify complex material:

> *"opted instead to write a different kind of book. He would treat the philosophical topics that were his subject as forming a complex landscape, and he would sketch those topics as sites within the landscape. He would then arrange these sketches of local regions of the landscape to form a kind of album. The sequences in the "album" would represent different traversals of the (conceptual) landscape. So in order to insure that the complex landscape would not be oversimplified, he would endeavour to "criss-cross" it in many directions; that is, the same sketches of specific issues (or cases) would reappear in different contexts, analysed from different perspectives." (Spiro and Jehng, 1990, p170)*

Through multimedia construction of *The Garden*, the researcher has externalised a concrete representation of the conceptual landscape of this study, which provides the reader with an alternate form of knowledge representation.

The repetition of certain theoretical elements in this thesis is in keeping with multiple traversals of *The Garden* from different perspectives. It is hoped in this way that a range of interpretations may be drawn from the study by the reader, in accordance with his/her prior knowledge and unique range of experiences.

### *7. Multimedia construction supports the development of higher order thinking.*

Higher order thinking is a natural consequence of constructionism. When reviewing the attributes of higher order thinking described by Resnick (1987) in Chapter Two, it is possible to identify a multitude of benefits associated with construction of interactive multimedia. Higher order thinking:

- is non algorithmic— the path of action is not fully specified in advance. The EDUM and G&T classes took different approaches to construction of interactive multimedia. With either a product (EDUM) or a process (G&T) focus, the path of action could not be fully specified in advance. Even a more planned approach with IMM production results in unexpected problems and requires iterative design. The process focus permits the learner to adopt the thinking style of the bricoleur or the planner.
- is complex— the total mental path is not visible from any vantage point. At any point in production, the focus must be directed at the process at hand (the high power objective). Reflection time permits the multimedia designer to withdraw to the low power objective, assimilate recent experiences and accommodate these in the next plan of action.
- yields multiple solutions— each of these have costs and benefits. Interactive Multimedia construction yields multiple solutions, whether the product or process focus is adopted. What differs in a group production exercise, is the nature of the process outcomes. Cooperative group work for product orientation requires individuals to collaborate then delegate ultimate responsibility for each aspect of the project. Multiple solutions to a design task will result not only from different group membership, but also from use of group members for different roles. Collaborative group work yields multiple representations of concepts at the screen or concept level. The group is then free to "play" with combinations of these representations until they are happy with a solution that represents group understanding, or if this can't be reached, they are free to display parallel forms of representation.
- involves nuanced judgment and interpretation. Decisions on interface design and interactivity require judgment and careful interpretation. They promote discussion, and identify the diverse range of user interpretations and misinterpretations. Neither icon nor command choices are free from ambiguity in multimedia design. Selection of media components or combinations thereof require nuanced judgment.

- applies multiple criteria, which sometimes conflict. The interactive multimedia designer, with a product or process focus, is involved in a complex process, with a range of conflicting issues. The product focus demands various combinations of technical, conceptual and creative expertise. The creative mind demands one style, while the technical mind may be limited in capacity to respond. Meanwhile, the conceptual mind is grappling with the relevance of the creative element to the overall message. The practical mind is worrying about cost and time factors, and the social mind is worrying about group dynamics. The knowledge designer with a process focus may face less technical demands, but the conceptual and creative elements are no less real, and time, expense and social issues are still important to establish some balance in the construction process.
- involves uncertainty— not everything which bears on the task at hand is known. The complex environment of production, or the new process of multimedia construction will lead the learner very quickly into new cognitive territory. There is no substitute for experience, and what sequence works for one student will not necessarily work for another. Multimedia production/construction in the classroom needs to be viewed as a meaningful learning exercise. The complexity of the path should be made explicit to the learner at the outset, within the framework of a challenging and exciting venture.
- involves self-regulation of the thinking process. This non-algorithmic, complex, uncertain yet creative process of interactive multimedia construction demands that learners acquire sound metacognitive skills— they need to plan, organise, monitor and reflect on the construction process. These skills then permit learners to regulate their own thinking processes.
- involves imposing meaning— finding a structure in apparent disorder. The process focus of multimedia construction is aimed directly at identifying structures in a grounded fashion. The product focus requires top-down analysis of "client" determined content to identify a structure which can be mapped to a multimedia product.
- is effortful— considerable mental effort is involved in the elaborations and judgments required. Students in the EDUM and G&T classes were highly engaged in multimedia construction for a lengthy period of time. They expended considerable effort in a positive and self-motivated way. For these students the exercise was meaningful and personally rewarding. From the researcher's perspective, considerable effort was expended in the construction of *The Garden*, with its associated presentations, project and tools. What was satisfying,

was the creation of a concrete representation of the study which could easily be edited and developed as future ideas evolve.

Perkins (1991b) referred to the cognitive load of constructivism for the learner— the complexity, the task management and the need to "buy into" this more involved way of learning. Constructionism, expressed as multimedia construction, appears to offer learners an easier inroad to constructivism from several epistemological vantage points:

> *"The computer, with its graphics, its sounds, its text and animation, can provide a port of entry for people whose chief ways of relating to the world are through movement, intuition, visual impression, the power of words and associations. And it can provide a privileged point of entry for people whose mode of approach is through a close, bodily identification with the world of ideas or those who appropriate through anthropomorphization. The computational object, on the border between the idea and a physical object, offers new possibilities." (Turkle and Papert, 1991, p181)*

Through group construction of a "concrete" object (Wilensky, 1991), learners can establish some common ground for discussion. Each contributes a unique perspective, based on prior knowledge which has filtered through a sociocultural lining (Alexander, Schallert and Hare, 1991). Once the object exists, its structure and functionality are open to further development, through the processes of negotiation and social construction of meaning.

### *8. The relationship between multimedia and learning depends largely on the active involvement of the learner in the knowledge construction process.*

The models discussed in Chapter Six related the activities of teaching and learning to student use or production of interactive multimedia. Within student production, the distinction was made between production with a product or a process focus.

The three models were:

- *Model A* —Teaching/Learning Through Use of Interactive Multimedia Products
- *Model B* — Teaching /Learning About Interactive Multimedia Production
- *Model C* — Teaching/Learning With Interactive Multimedia Construction Tools

The type of learning emphasised in these models relates closely to what Jonassen (1995, pp60-61) describes as *meaningful* learning, which is:

- active — learners process and are responsible for the result

- constructive — learners accommodate new ideas into prior knowledge
- collaborative — learners work in communities
- intentional — learners are actively and willfully trying to achieve a cognitive objective
- conversational — learning is a social process involving dialogue
- contextualised — learning tasks are based in a meaningful real-world task
- reflective — learners articulate and reflect on what they have learned and the processes involved

This orientation to learning precludes from use a considerable amount of software in Model A, if the learner is not at least placed in an active mode, with access to some form of knowledge construction tool. This means that if the software itself does not support active learner construction, the teacher needs to create the additional environmental conditions to facilitate meaningful learning.

The conditions for meaningful learning are well catered for in both Model B and Model C. In these models, learners are active product or knowledge designers, collaborating or cooperating with peers in a creative process which demands discussion, negotiation, reflection, organisation, management and a positive group attitude for success. Student selection of the task goal ensures that the context is relevant.

### *9. The roles of teacher and learner need to change to take advantage of what constructivist theory and computer orchestrated interactive multimedia have to offer learners.*

Fosnot (1996) describes the constructivist classroom as "a mini society, a community of learners engaged in activity, discourse, and reflection." The roles of the constructivist IT teacher and learner are complementary roles. The teacher is a facilitator of process, a task or tool designer, a resource organiser and a source of metacognitive support. The learner is an active resource producer and collector, who takes responsibility for personal or group resource management, shares strategies, and is able to work collaboratively and cooperatively. These complementary roles support the criteria for meaningful learning, as long as the tasks are contextualised.

Technology has three roles in the classroom (Jonassen, 1995). It can be used as a tool for productivity, as an intellectual partner (mindtool), and as a source of context. Technology used purely as a source of context— whether that is a simulation of real-world problems, a range of alternate perspectives, or a community of learners to support discourse, is not enough. This context is transitory, and the benefits are wasted without the use of cognitive tools, which permit the learners to construct their unique representation based on their experience of that context. Access to the WWW now extends the classroom context globally. What learners require is teacher support to enable them to capitalise on the benefits of an intellectual partnership with the computer. Multimedia/hypermedia design is an example of one such mindtool which is very effective.

## 7.2 Implications of the Research Findings

Based on the study findings, which have emphasised both constructivism and constructionism from teacher, designer and researcher perspectives, the construction of interactive multimedia has received strong support as an effective means of assisting students to develop higher order thinking and problem solving skills. It is a collaborative experience which stimulates meaningful learning, and alters the roles for teacher and learner in the classroom.

These findings carry certain implications for teachers, designers, researchers and learners.

### 7.2.1 Implications for Teachers:

*1. Teachers should become familiar with the design process.*

Harel (1991b) identifies design as a central principle in education:

> *"There is a need to take advantage of the trans disciplinary, integrative, and comprehensive nature of any design process, and to explicitly include it into the larger context of human development and schooling. ... It is not just another skill we need to learn in school so we can use it when we grow up, to make our society's industry profitable (a common argument among some people who wish to bring design education into schools). Rather, design is viewed here as an empowering principle, as a discipline which facilitates other learning, and which marries cultural background, school activities, thought, action, creativity, construction, and reflection." (Harel, 1991b, pxx)*

The team of teachers designed the G&T class environment each week in response to the needs of the students. *Figure 7.1* illustrates the key aspects of this regular process.

Following the backup of student work, class activities were discussed, notes were recorded, and reflection was prompted by phone contact with another team teacher. Analysis of class needs led to planning and design of a HyperStudio® stack to display recent student work for group discussion and strategy sharing. Teacher activities within the classroom typified those of a facilitator.

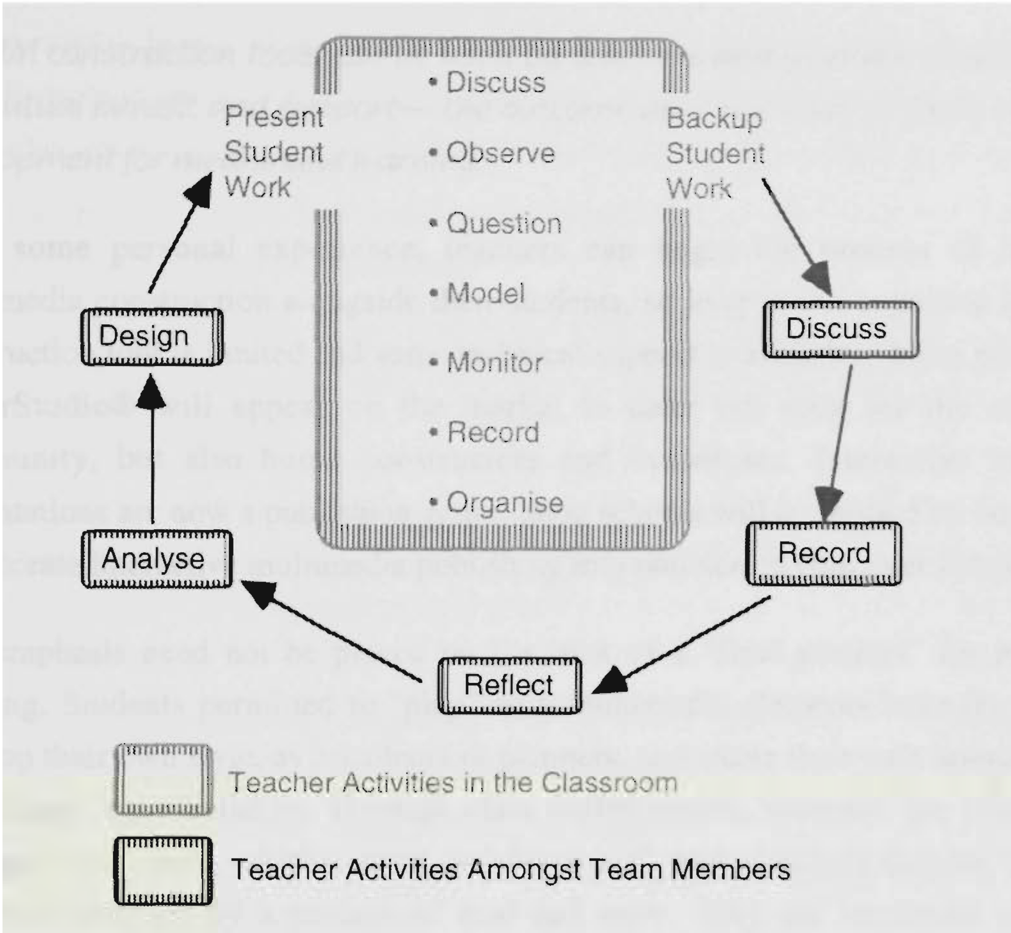


*Figure 7.1 : The Class Design Cycle with the G&T Students*

A teacher who designs classes using this adaptive approach to support multimedia construction requires sound metacognitive and interpersonal skills. While students manage the load of their projects, the teacher manages the metacognitive load of the class as a whole.

*2. Teaching IMM production is a specialist job which requires considerable time.*

Teaching interactive multimedia production is not a simple activity, and learners will approach the demanding task with enormous frustration, tempered by excitement. The parallel development of skills, conceptual understanding and creative expression is probably best learned through cognitive apprenticeship, which requires extended periods of time and repeated cycles through the production process to gain understanding at any deep level. Commercial multimedia production is a rapidly moving target even for professionals who make it their living

Teaching school students media production techniques is largely futile at present, while digitising hardware continues to develop at such a rapid rate. Schools can't easily afford current production facilities. Meaningful student learning is not dependent upon the production skills they can acquire, though these do tend to give some students more self-esteem, based in part on a sense of control over the equipment.

*3. IMM construction tools can be used by teachers and learners simultaneously for mutual benefit and support— the outcome does not have to focus on product development for meaningful learning.*

With some personal experience, teachers can begin the process of interactive multimedia construction alongside their students, so long as the cognitive load of the construction tool is limited and some technical support is available. More products like HyperStudio® will appear on the market to cater not only for the educational community, but also home constructors and businesses. Interactive multimedia presentations are now a publishing genre. Soon schools will be pushed by businesses to incorporate interactive multimedia publishing into policies on computer literacy.

The emphasis need not be placed on the look of a "final product" for meaningful learning. Students permitted to "play" with multimedia elements have the chance to develop their own style, as bricoleurs or planners, and create their own unique forms of knowledge representation. Through class collaboration, students can communicate amongst their peers, whether local or "electronic", and gradually develop a sense of effective interface by a process of trial and error. They are immersed in the best environment for growth— an environment in which their work is in a constant state of formative evaluation by the "authentic" target audience.

### 7.2.2 Implications for Designers

*1. Design should not focus purely on top-level production.*

The rapid prototyping which is a feature of the development of "disposable software" and classroom-based cognitive tools such as *Themes* speeds up the cycle of formative evaluation and increases the repertoire of effective learning strategies available to developers. These strategies can then be incorporated in more sophisticated products with increased certainty.

It is most likely that the creative features of future software will emerge from Primary School students who are now fluent audiovisual users. Simple tools should be developed for evaluation by these students— our future developers. Their intuitive design ability is quite prolific and very creative.

*2. Designers should develop top-level products which promote constructionism.*

Constructivist design of democratic information rich environments should not only provide students with the following conditions for information presentation and access:

- a clear means of navigation to allow them to select from multiple pathways
- clear presentation of information in meaningful chunks to allow information access via a range of mechanisms
- inbuilt activities with clear support to enable less adventurous users to develop confidence and competence with the medium before they are ready to design their own challenges

but also:

- cognitive tools to permit the student and teacher to design their own activities, pursue their own questions, and collect and re-construct their own knowledge representation
- metacognitive tools to support the student and teacher with a range of learning strategies, such as planning a solution, techniques for data collection and annotation, advice on different ways to organise information, and tools to enable reflection at the conceptual level— such as brainstorming and diary facilities.

*3. Designers should develop cognitive tools for learners across a range of disciplines.*

Cognitive tools are required at numerous levels. Within disciplines they can provide shells for data structures which are quite discipline specific. Across disciplines they can provide shells for common information structures or means of data processing and organising. At the individual or group level, once students and teachers begin to produce multimedia and collect a vast array of resources, the need for organisation, management and integration of these elements into a meaningful personal or group information system becomes apparent. Resources need to be managed well to permit the individual or group of users to assimilate and accommodate new ideas in the move from novice to relative expert.

For a teacher, class-generated work resulting from student immersion in a particular issue rapidly recedes to become the attachment to a single node in a growing electronic "map" of concepts and class work. If the teacher is provided with tools to facilitate the cumulative organisation of student work, he/she can construct a visual representation of this information system. This view is the record of student work— the relevant context within which to anchor new ideas which will be personally meaningful to the students.

The ability to retain and build an information and ideas structure is in keeping with the concept of anchored instruction (Bransford et al., 1990). Students and teachers can collaborate to build an information system as a specific community of learners. They have the opportunity to experience sustained thinking, common to experts in a discipline.

This information system may require many tools to manage—such as tools to map concepts, tools to generate presentations, tools to permit students to build self-assessment modules, tools to identify keywords, and tools to view data across multiple forms of representation to suit different learning and information processing styles. Tool designers have the opportunity to use the latest techniques in interface design to support very powerful means of representing information to facilitate deep knowledge structuring on an individual or group level.

### 7.2.3 Implications for Researchers

*1. Researchers should explore publishing paradigms to include interactive multimedia as a valid and unique form of representation of research results.*

Constructivist evaluation calls for multiple forms of representation. The construction of interactive multimedia is a powerful learning tool to permit researchers to represent their understanding in a visual and non-linear form which can complement the traditional thesis format.

Wills and Swart (1994) note:

> *"Most multimedia productions are currently too rooted in the media from which they originate. To avoid framing new technologies in terms of the ones with which we are already familiar, multimedia producers and interactive publishers need a new grammar for the design process - a grammar that is not rooted in the vocabulary of traditional media productions. A new grammar will facilitate the development of new infrastructures, policies, professions and cultures around the activity of interactive publishing." (Wills and Swart, 1994, p92)*

When standards of publishing are established, there is a convergence of style which may become too restrictive to allow researchers to capitalise on the benefits of multimedia construction as a grounded research tool. While research may be presented in a multimedia format which emerges as part of the interactive publishing paradigm, that is not the same as the use to which the researcher has put multimedia construction in the development of *The Garden*. The researcher challenges the potential dominance of the publishing paradigm as the complement to thesis presentation. Do we wish to impose a grammar on a constructionist activity?

Harel (1991a) featured video in the development of a multimedia research tool. Hours of video footage were collected using video to record interviews, act as the silent classroom observer, and function as a notepad to specifically record events or objects. This footage was then edited and accessed through a sophisticated video editing tool (Segall, 1991). The researcher has relied heavily on text, collections of student work and some audio files to provide the raw data for development of a visual metaphor in which to anchor both raw and processed data.

Hopefully many different multimedia "languages" will evolve in response to the individual needs of researchers, to permit use of similar cognitive tools in vastly different ways. To destroy the versatility of these tools would be to waste their greatest asset— flexibility.

*2. Researchers should explore strategies for the development of student and discipline based personal information systems.*

What constitutes the next stage beyond a project? What are the logistics of management, and what are our current limitations?

The second and third questions are practical issues. No doubt well organised teachers will deal with them in their usual strategic manner, and answers to these questions provide the vital body of knowledge necessary for implementation. However, the first question is the intriguing one, since it provides a natural link between process and product.

If the focus is moved from teacher to learner through the capacity to build electronic information systems and use powerful mindtools, the learner has the capacity to build a personal processfolio, which expands and evolves with deepening understanding of the information structures. Minor publishing "products" become a tertiary level resource in a landscape of media categorised by the learner. Primary resources may constitute individual media elements, while secondary resources may represent screen-sized media compilations.

The ability to re-access and edit material is what makes electronic storage so powerful. Components can be stored in varying combinations, to be re-compiled as the need arises, to cater for a different audience or purpose. The individual content expert has the mechanism for maintaining a record of the change in their ideas, depending on how they choose to structure their information system. While there is a cognitive load in establishing the system, there is a freeing up of memory to allow the learner to shift emphasis from memory work and calculations to pattern identification, coding and organisation. The mental schema of the learner become explicit via the constructionist process, and more accessible to others.

Researchers need to permit students to move beyond the individual project-based "product"— to enter the realms of a long term learning "process" of knowledge construction, facilitated by electronic information systems. Individual publishing products relate to the evolving information system (process) as parts to a whole.

*3. Researchers could explore the relationship between personal experience and ability to support students in the multimedia design process.*

Does the teacher *have* to experience the design process to support students in this endeavour? The researcher has noted the benefits of experience with the design process for teaching about production and through construction of interactive multimedia, and has recommended this experience prior to embarking on these ventures in the classroom. Is this stance heavily biased by the researcher's personal preference and individual teaching style?

From the researcher's experience, when teaching about multimedia construction and production as an experienced producer you understand:

- the complexity of the task
- the ill-structured nature of an interactive multimedia project
- the process of resource management
- the iterative nature of design, and the need to prototype
- the difference between ideas on paper and on screen
- how perspectives change with access to media— the balance you achieve between text and complementary media
- the importance of evaluating media— what best represents what you want to convey?
- the difference between expectations and reality
- the change in focus from text to graphic dominance

If this experience is necessary, will teacher support for student construction and production of interactive multimedia be provided by specialist information technology teachers? Can these specialists team teach with the regular classroom teacher? This would provide one means of teacher in-service, and allow the specialist IT teacher to expand the repertoire of effective teaching strategies using computers across a broad range of students, subjects, and tasks.

### 7.2.4 Challenges for Learners

Teachers, designers, researchers and students are all learners in a time of rapid change. Teachers are challenged to cope with their changing role— instituted by developments in technology which facilitate the translation of constructionist principles into the classroom. Software designers are challenged to adjust to the needs of the public, private industry, and multiple parallel systems of education which support a range of learning outcomes. Researchers are challenged to learn not only about the changes in education facilitated by the use of new computer based tools, but also how to use these tools to improve the research process itself. Lastly, students are challenged to adjust to the variety of teaching/learning environments across different teachers, forms of educational technology and educational systems. There are several implications for all learners.

*1. Metacognitive skills are vital to support more self-regulated learning.*

To capture the full learning potential of interactive technologies in a constructivist environment, learners need to develop a slightly different set of skills from the ones currently promoted by content driven curricula. They need:

- metacognitive skills to set goals, make plans and monitor a more self-regulated learning process
- information appraisal and selection skills to cope with abundant information
- knowledge construction and conceptualisation skills to develop an evolving personal information system
- multimedia publishing skills to report specific task-based findings to a target audience

Currently in many learning environments there are not the tools or the strategies to support the development of these skills which enable learners to become more self-regulated. Financial and practical reasons such as machine security provide only one side of the story. The other side, which is perhaps the greater barrier to implementation, stems from a sub-threshold level of support in society for the principle of constructivism/constructionism— a principle which applauds diversity and flexibility of learning outcomes. A principle which would remove the restriction of standardised tests, in order for learners to experience learning environments which foster both social/collaborative and individual growth.

*2. A process focus can be fostered by the construction of personal information systems.*

Learners need to acknowledge the uniqueness of their own understanding, and the value of maintaining an evolving body of knowledge on which to reflect. This constructionist "processfolio" indicates the capability, versatility and flexibility of its creator to any future employer. It is tangible evidence of productivity and communication skills, rather than a quantitative indicator of potential.

When learners reflect on what they have done previously, they have the opportunity to compare and contrast, to become aware of the changes in their attitudes and understanding over time. Education does not remain a series of compartments which are dealt with separately then forgotten, as the next external goal is set. Education becomes a learner-centred process which retains continuity, because the learner assumes responsibility for maintaining that continuity.

*3. A product focus can be fostered by the development of sound interactive multimedia publishing skills.*

There is a complementary relationship between process and product. Learners should maintain an evolving personal information system to enable them to become more literate producers— people who can clearly communicate their depth of understanding to a range of groups for a variety of reasons. Publishing skills are refined through use of software, playful construction and publication of products.

## 7.3 Probable Major Limit to Growth

### Standardised Tests

Standardised tests provide a major barrier to more creative constructivist application of computers within learning environments. There is little motivation for teachers to explore strategies for more student-centred learning when they are under severe time pressure to complete curriculum objectives. Reeves and Okey (1996) note:

> *"Traditional assessment has been a major force in retarding educational reform, and it could have the same deleterious effect on the development and implementation of constructivist learning environments. Previous educational reforms have been prematurely held accountable for their effects using inappropriate outcome measures such as achievement tests that are poorly matched to the goals of innovative programs (Fullan, 1993). The innovation process itself is often stymied by teachers fearful of straying from established*

*curriculum and methods lest their students falter on standardized tests." (Reeves and Okey, 1996, p193)*

Higher order thinking and problem solving skills are fostered by the construction of interactive multimedia, and various ways to evaluate higher order thinking are now emerging. Reeves and Okey (1996) discuss such techniques as authentic assessment, performance assessment and portfolio assessment, acknowledging that "assessment in constructivist learning environments is (and needs to be) as varied and broad as the environments themselves." They also note that policies, methods and technologies for alternative assessment will need to keep pace with the development of constructivist learning environments if principle is to reach broader practice.

## 7.4 The Self-Regulated IT Literate Learner of the Future

The researcher speculates that the classroom of the future could present students with an integrated interface to a global supply of resources. These resources could represent anything from individual media elements, to huge databases of information. Students, armed with their personalised set of cognitive tools, could collect and structure their own "virtual" compilation of resources in a personally meaningful style. This process could be assisted and modeled by the facilitator, who may determine the character of the resource interface (graphically) and the deeper structure and nature of content which is not accessed via the WWW. Both facilitator and students could evolve design skills and learning strategies as a learning team.

The goal of the future is self-regulated learners. By developing personal information systems, students can begin to understand the content, application, integration and flexibility of a knowledge domain. Such flexibility is what allows for growth of understanding and acceptance of change. While evaluation in its current form restricts curriculum development, there will be little change in the ability of teachers to provide students with this kind of learning opportunity, to extend them into higher order thinking. Knowledge is not important in isolation, but in its relationships with activity and culture. Learning through construction of interactive multimedia provides one pathway— hopefully a well worn pathway, which leads straight to this goal.

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# *Appendix A - Sample Class Activity Sheet EDUM 221*

## Class Activities EDUM 221

Thursday, May 5, 1994

*****
**Today is Expert Status Evaluation and HyperCard progress!**
*****

*Practical Component*
There are several things which we hope to achieve in our practical component today (there will be no lecture presentation by John today):

1.30pm (let's be optimistic!)
1 ***View*** the Technical details stack to:

- review what we said in group discussion 2 weeks ago
- note any technical discoveries of the week!

2 ***Record*** in a table for future comparison what we know about resource production and presentation in HyperCard 2.2 - we didn't get to this 2 weeks ago!.

3 ***View*** two ways colour is added to HyperCard 2.2:

- using the buttons generated from the "Media" menu of the stack "Begin with HyperCard" - only this stack has that menu
- using the "Color" menu of HyperCard 2.2 - using the colour tools palette - note this changes your stack once you open these, and screen to screen movement is slowed slightly.

4 ***Undergo "Expert Status" evaluation*** : (*2.00 pm* )

- Scanners should be able to be tested straight away
- Sound people - pick functional machine! (AIFF and movie formats)
- Video digitisers -at the 950 - notes are fine.

5 **Individual** HyperCard Project and digitising time : ( *3.00 pm* )

- those of you finished your HyperCard stack should submit the electronic copy to Christine (she will copy it to a cartridge)
- Those who need scripting help should gather together
- Those who need to digitise resources should help one another
- Those finished all that should begin to organise group project material ready for discussions at 4 pm.

6 **Group Project** Discussion : necessary round table conference! ( *4.00pm*)

# Appendix B - Resource Format Sheet—EDUM 221

**EDUM 221- HyperCard 2.2 Resources and Use**

Text

| Obtain by | Format | How Incorporated |
|---|---|---|
| | | |

Pictures

| Obtain by | Format | How Incorporated |
|---|---|---|
| | | |

Sounds

| Obtain by | Format | How Incorporated |
|---|---|---|
| | | |

Movies

| Obtain by | Format | How Incorporated |
|---|---|---|
| | | |

Animation

| Obtain by | Format | How Incorporated |
|---|---|---|
| | | |

# Appendix C - Sample Script Document—EDUM 212

This document reads best when displayed in a mono-spaced font

**STACK**: Search Menu Read Write Demo

**BACKGROUND**: bkgnd id 2615

**CARD**: Reading in a File

CARD BUTTON SCRIPTS

```
•••BUTTON: card button "Read in a file"
on mouseUp
  answer file "Import which file?" of type text
  if it is empty then exit mouseUp
  put it into fileName
  open file fileName
  read from file fileName until end
  put it into card field "Holder"
  close file fileName
end mouseUp
```

```
•••BUTTON: card button "Read Until Return"
on mouseUp
  answer file "Import which file?" of type text
  if it is empty then exit mouseUp
  put it into fileName
  open file fileName
  read from file fileName until return
  put it into card field "Holder"
  close file fileName
end mouseUp
```

**CARD**: Writing Out

CARD BUTTON SCRIPTS

```
•••BUTTON: card button "Field Length"
on mouseUp
  put the number of chars in card field "Holder"
end mouseUp
```

```
•••BUTTON: card button "Write to File"
on mouseUp
  put the short name of this card && ".text" into fileName
  ask file "Export text to what file?" with fileName
  if it is empty then exit mouseUp
  put it into fileName
  open file fileName
  write card field "Holder" to file fileName
  close file fileName
end mouseUp
```

# *Appendix D - Sample Skill Sheet—G&T Class*

## TOBY

My Computer Skills and Experience at Koonawarra PS:

**So far in computer lessons I have:**

1. Written a short piece of text including the words:
    - •secrets
    - •cat (or another animal of your choice)
    - •exploration or discovery..........................................................................

2. Illustrated my text with a pencil or colour drawing...................................

3. Recorded me reading my story into the tape recorder or computer....

**So far using "HyperStudio" I have:**

Typed in a story in a field ..........................................................................

Made a button to go to the next card.......................................................

Made a new card in my stack.....................................................................

Pasted in a picture saved as a PICT file on my floppy disk..........................

Made a button to play a sound ...................................................................

# Appendix E - Alphabet Brainstorming—G&T Class

Names:________________________________________

## Ideas List for Projects

There are many possible things we could make multimedia programs about - and one good way to generate some great ideas is to play the old game of exhausting the alphabet.

Work in pairs to add your suggestions:

| Letter | Example | Your Suggestions |
|---|---|---|
| A | animals | |
| B | bronze | |
| C | cauliflower | |
| D | danger | |
| E | energy | |
| F | frogs | |
| G | ghosts | |
| H | holidays | |
| I | Iron | |
| J | justice | |
| K | keys | |
| L | light | |
| M | memories | |
| N | neighbours | |
| O | order | |
| P | pirates | |
| Q | quality | |
| R | railways | |
| S | sailing | |
| T | time | |
| U | underwear | |
| V | victory | |
| W | water | |
| X | xylem | |
| Y | yellow | |
| Z | zealous | |

# *Appendix J - Brainstorming with Interrogatives—G&T Class*

Names:________________________________________

Working with a Project Idea

Topic Given/Chosen: ______________________________

Once you decide on your project, here are some things you need to think about first.

Work in pairs to brainstorm some ideas for your project:

(A) Use the following words to ask yourself questions about your topic. List the questions below each word your program would answer.

**Example:** if my project was about "My School", some of the questions my program might answer are:
- "Who are the people you would find in my school?"
- "What happens during a typical day at school?"
- "Why do you need to wear a uniform at school?"
- "Where is your school located?"
- "When do you have sporting activities at school?"
- "How do you get to know others at your school?"

Now you write some questions your project would answer:

- Who

________________________________________________________________

____________________________________________________________

______________________________

- What

________________________________________________________________

____________________________________________________________

_________________________________

- Why

________________________________________________________________

____________________________________________________________

_________________________________

- Where

- When

- How

(B) What resources would you like to use for this program?

**Example:** for the project "My School", I might like to have:
- pictures of the buildings and inside the classrooms, pictures of some of the sporting events, drawings the students had done and some art work.
- sounds of children at play, the choir singing, some typical question time in class
- movie of a play the class put on, and some movie of the playground at lunch time.

- Pictures/Drawings/Paintings:

- Sounds/music/voices:

- Movie clips/animation:

## *Appendix G - Scanned Image List—G&T Class*

Extra Images Scanned by Mrs Brown for Class 5/6M for Thursday, July 21 1994

Group Name: **HORSES**

Please note: the **book number** refers to the order of scanning and simply helped me to identify a group of images from the one book.

Hall, T. (1982). Horses Down Under. Sydney: Golden Press.
**Book 2**

p38 Horses Polo
p22 Quarter Horse

Dell, C. (1985). Superbook Horses. London: Kingfisher Books.
**Book 11**

p4 Horse Ancestors
p6 Points of Horse
p11 White Horses
p10 Wild Horses
p13 Alexander
p12 Caligula
p12 Napoleon
p13 Robert E Lee

Mead, H., & Fulwood, N. (1983). Let's Learn About Animals... At the Zoo. The Jacaranda Press.
**Book 14**

p13 Zebra

Wilkinson, M. (1983). The Phar Lap Story. Budget Books.
**Book 18**

Cover of Phar Lap

Rodgers, F. (1991). Animal Art. London: Scholastic Publications.
**Book 19**

p32 Pegasus

Alcock, A. (1988). Horses Horses Horses. Leicester: Galley Press.
**Book 22**

Inside Cover Horse
Title Horses
p3 Cover Horse
p4 Wild Horses

Edwards, E. H. (1991). The Kingdom of the Horse. London: Salamander Books Limited.
**Book 23**
p20 Grey Arab
p21 Brown Arab

Owen, R., & Bullock, J. (1992). The Complete Book of the Horse & Rider. London: Chancellor Press.
**Book 24**
Title Image -Head

Edwards, E. H. (1991). The Ultimate Horse Book. Sydney: RD Press.
**Book 25**
p8 Brown&White Horses
p13 Viking Tapestry
p18 Gaits
p19 Canter
p19 Gallop
p19 Trotting
p19 Walking
p20 Coat Colours
p26 Brown Horse
p198 Tack
p206 food
p207 Food
p208 Poisonous Plants
p210 Foal Development
p210 Horses Mating
p212 Mother & Foal
p224 Hunting Kit
p226 Jumping & Faults
p227 Evening
p230 Polo Gear

# Appendix H - Pre-Course Questionnaire—EDUM 221

## Pre-Course Questionnaire

**Student Code:**

(month of birth) _ _

(middle initial or if none, that of your mother or father) _

(street number, or unit or room number if in a hall of residence) _ _

(last two digits of your postcode) _ _

1. **Learning Style** - How do you prefer work to be presented or available, to assist you in learning? For example, do you like to listen, see, talk it out, act it out, draw it (to name a few) - what combination of these and/or others do you think helps you learn more easily?

2. **Project Work** - How do you usually approach a project? What strategies do you use to find, collect, collate and synthesise information?

3. **Group Size** - Do you normally like to work in a group or individually? Are there any special circumstances when you feel differently?

4. **Preferred Mode of Expression** - How do you normally like to express yourself? (Essay, speech, project, computer presentation, play etc) Are you comfortable with a range of these depending on the task and the content?

5. **Evaluation** - How do you normally like your work to be evaluated?

| **Panel One:** | **Panel Two:** |
|---|---|
| o Single marker | o mastery of material mainly |
| o Group of markers | o grading of material mainly |
| o Peer marking | |

6. **Computer Use** - How do you feel about using the computer to do some of your work? Would you rate yourself as a person who:

o Couldn't live without the computer

o Often uses the computer but is still quite happy to put pen to paper to think

o Likes to use the computer for final work but drafts ideas on paper first

o Always likes to write things out and doesn't like having to word process them

o Doesn't like using the computer

o Doesn't usually have a computer to work with but wants to

o Doesn't have a computer to access and doesn't want one

7. **Computer Experience** - What past experience do you have on the computer?

o Word processing

o Spreadsheet

o Database

o Graphics

o Programming

o Games

o Work tailored package

o Others................................

8. **Work Organisation** - Do you normally re-use work you have done before? How would you keep track of this previous work?

9. **Concept Development** - Do you normally re-access and re-purpose work you have done before to link it with other themes?

______________________________________________

______________________________________________

______________________________________________

______________________________________________

10. **Preferred Problem Solving Style** - When problem-solving, do you like the problem to be very restricted with one best solution, or do you like to be able to suggest many possible solutions?

______________________________________________

______________________________________________

______________________________________________

______________________________________________

11. **Population Statistics**- Please select the appropriate box in each section

(a) Your **age** is in the range:

o 17 - 20 years

o 21- 30 years

o 31 - 70 years

(b) Your **present course** of study is:

o the first since leaving school

o the second since leaving school

o at least the third course of extra study you have taken since high school

(c) Your **gender**:

o female

o male

12. **Reason for Course Selection -** Since this is an elective subject, is there any significant reason why you chose it? Was it an area of particular interest and expertise, or did you feel it might be particularly useful in teaching, or do you feel it offers diverse career opportunities … or did you not find any options great (this seems as good as any).?

______________________________________________

______________________________________________

______________________________________________

Thank you very much for your time and thoughtful comments. Please be assured none of this material relates in any way to subsequent evaluation. Christine Brown

# Appendix 9 - Post-Course Questionnaire—EDUM 221

## Reflections and Suggestions - EDUM 221

**Student Code:**

(month of birth) _ _
(middle initial or if none, that of your mother or father) _
(street number, or unit or room number if in a hall of residence) _ _
(last two digits of your postcode) _ _

Let me begin by saying "Thank You" for your company, enthusiasm, inspiration and most of all, your youthful vigour!

The course has concluded, but some exams and prac work lie ahead of the break. May I request 10-15 minutes of that precious break for some of your thoughtful comments about interactive multimedia (what we've just done!).

You have the stamped, addressed envelope, so please just drop the completed form into the nearest mailbox.

1. **Grouping** - We worked at times singly, in pairs or in groups of various sizes. How effective did you find this mix of strategies for learning? Why?

2. **Evaluation** - There was a blend of mastery and grading. Now you have finished the course, how would you recommend we evaluate such skills and tasks as those you accomplished?

3. **Course Application** - With the knowledge and experience of such applications as HyperCard, HyperStudio, SoundEdit, PhotoShop and more, how do you see yourself using this knowledge and these skills in your course at Uni?

4. **School Application** - In what ways might you use what you have learned in this course in the classroom? (It could be something you produce or something you get the children to produce)

5. **Long term value** - If you had no further chance to practise your new multimedia skills this year, do you think this course would have offered "value for money"? Why?

6. **Additional Comments** - Please feel free to make any:

I am hoping to interview each of you next semester once things settle down to routine, so you don't have to spend much time on extra comments. I thought this might be a more private forum for some of the negative aspects you may wish to air.

Thank you very much for your time and thoughtful comments.

Christine Brown

# *Appendix J - Interview Questions—EDUM 212 Class*

**Interview Format for Second Year Students of Christine Brown in 1994**

## A - **BACKGROUND**

1. Can you tell me any memorable moments of the course?

* Student list and Tasks list to prompt memory

## B - **SKILLS**

2. There were many skills you learnt in the course.

(a) How much do you feel you improved in each of the following skills?

* Skills checklist

(b) What was the *hardest* skill for you to acquire?

(c) Can you tell me *why* ?

## C - **GROUP WORK/SHARED WORK**

3. (a) Think - but don't tell me any name/s - Was there one person or more in particular you found very beneficial to work with as a learner? [yes/no]

(b) Can you now express what the qualities of that person were that made you feel that they helped you learn?

## D - **SHARED IDEAS**

4. At times I talked with you as a group of learners, and at other times I asked you to imagine yourself in the teacher's shoes, seeing the "other side".

Was my sharing of WHY I organised things a certain way as the teacher helpful to you at all as a student teacher, or did it merely get in the way of your learning?

E - **TEACHER ATTRIBUTES**

5. There are four *phrases presented here which relate to teacher attributes:

- interpersonal skills * on Prompt Card
- organisation
- technical competence with equipment
- software and print support material - eg "Begin with HyperCard" stack and accompanying print tutorial material

Would you like me to clarify what I mean by any of these?

(a) From your perspective AS A LEARNER using multimedia, how would you rate the importance of each of these attributes in your teacher, on a scale of 1 - 10?

(b) Now, I'd like you to imagine yourself AS THE TEACHER in a multimedia classroom. How would you now rate, on a 1-10 scale, the importance of each of these attributes in yourself to the quality of your teaching?

F- **TEACHING STRATEGIES**

6. Can you suggest some strategies for teaching some of the skills we learnt?

* Skills Checklist as prompt if needed

G - **EVALUATION**

7. How would you *evaluate* student work produced in a multimedia format?

H- **BARRIERS TO IMPLEMENTATION**

8. What do you feel are the biggest barriers to teachers using the technology?

* Prompt lists:

- lack of equipment (hardware) and memory (both RAM and Disk space)
- lack of technical skills
- difficulty monitoring student work
- difficulty evaluating student work to fit assessment criteria

Please suggest any others which spring to mind.

Thank you very much for your time, patience, and mental effort!

# *Appendix K - Interview Questions for Sue—G&T Class*

**Questions for Sue Macdonald, September 19, 1994**

1. For you as the classroom teacher, how has the computer component impacted on the class this year?

2. What concerns has this given you with the program you had written?

3. Has this computer session allowed you to get to know the students more, by observing them under someone else's instructions?

4. What skills do you notice the children have acquired through the computer time?

5. The Children have used the video camera, the tape recorder, and the computer as part of the technology. Could you tell me how you think each of these has affected the children?

The Tape Recorder...

The Video Camera...

The Computer use with HyperStudio...

6. The project idea was chosen to allow the children long term exposure to one thing to gain the feel of an expert, who can re-visit material over again. Do you feel the children are tired of the one thing, or have they gained from this experience?

7. Alternating audiovisual and computer work was done initially to allow the computer groups to work efficiently. It has had some other spin-offs. Would you like to comment?

8. We have really been a team in this computer time - You , me, Lara and Chester. This is not realistic in the regular classroom. What aspects of what we have done this year do you feel could transfer to the regular classroom?

9. Have you enjoyed the computer time, or felt it an intrusion and burden?

10. How would you change things next year, if the same team were present?

## Appendix L - Class Process—EDUM 221 Class

*Class 1* : A university wide power failure left the class with simple pen and whiteboard functionality. John introduced the concept of variation in program style, and design statements; Christine discussed evaluation, practical work, then took student photos as they filled in the questionnaire.

*Class 2* : John demonstrated MYST and RED SHIFT, then discussed the process of Instructional Design as a move from needs, tasks and learners to metaphor and strategy, then interaction. Christine showed the HyperStudio Tutorial video, then students moved to machines in pairs with their tutorial document, to complete the construction of a stack encompassing key functionality. Colour Scanning was demonstrated for "expert status" group.

*Class 3* : John reviewed instructional design as "ADDIE"; introduced the video camera, discussed shots and implications of quicktime for shot composition; video was recorded. Christine discussed the relationship between program structure (tree, hub, linear ...) and content access, demonstrated HyperStudio access and a commercial stack, then distributed tasks for students to complete in pairs. Video digitising was demonstrated for "expert status" group.

*Class 4* : John discussed the question episode, then the group project process as definition of problem - design brief - storyboard-prototype - final product. Group project ideas were brainstormed. Christine demonstrated technical findings, animation, and performance support stacks. Students continued work on HyperStudio tasks in pairs. Sound digitising was demonstrated for "expert status" group.

*Class 5* : John ran group discussion, which split between a game and resources project based on the Australian Identity for the 2000 Olympics; Christine organised the "Show and Tell" demonstration by students of their HyperStudio tasks. This was video recorded.

*Class 6* : Full Practical Class. Christine reflected on student HyperStudio work, summarised new findings with technical details and discussed evaluation. Resource formats for HyperStudio were discussed and entered in a table for future comparison with HyperCard. The HyperCard tutorial was demonstrated live and video recorded for those people who were absent. Students completed the HyperCard tutorial exercise, then returned to digitising skills.

*Class 7* : John discussed interface versus screen design, then demonstrated SAN DIEGO ZOO followed for comparison by COUNTDOWN. Christine handed out design statement copies for students to read the work of others. Group project discussion centred on resources required for the class project group then the games group. Students were selected to focus on specific resource production.

*Class 8* : John covered evaluation of software. Christine was not present due to illness. Students practised resource digitising.

*Class 9* : Full Practical Class. Christine demonstrated the latest findings with video and sound digitising; Resource formats for HyperCard were discussed and compared with HyperStudio; Color Tools in HyperCard were demonstrated; "Expert Status" was evaluated. Work continued on individual HyperCard projects. The class ended with discussion on the group project and demonstration of Glenn's horizontal scrolling image of the sidewalk.

*Class 10* : Full Practical Class. Students filled in the EDUM Thoughts stack. The rest of the time was consumed by a very informative HyperCard "Show and Tell" session of 14 projects.

*Class 11* : Full Practical Class. Christine demonstrated a possible link mechanism for multiple stacks, including all the HyperCard task stacks from the previous week. Students then chose sections for resource production, encompassing video, audio, graphics and data processing. The ion camera was used for a range of additional shots. Template stacks for different areas containing notebook and standard navigation were the springboard for production. Video was a highlight of the class.

*Class 12* : Full Practical Class. Last minute production prior to the lengthy "Show and Tell" session, parts of which were video recorded. A considerable audience was present for this demonstration.

Full details of these classes are available in the "Teacher Notes" on the ground beneath the EDUM tree in *The Garden*.

# Appendix M - HyperCard "Show and Tell"— EDUM 221

*Stack* - "***Gabrielle Louise Hindmarch***"

This is Belinda's niece, who has just started school and is in a talented class in computers after school. Belinda thought since they were using HyperCard that Gabby would like to see this stack. The images are brought up by buttons apart from the first card, and sounds are only played when the user selects them.

*Comments by Christine*: using the Picture XCMD the images can extend beyond the stack window. You can also have a lot of images on one card when brought up this way with buttons.

*Stack* - "***Glenn's Stack***"

"This stack is completely inane and uneducational!" (Glenn) However, Glenn went on to show some great features. He explained how he did the animation as images laid down like HyperStudio does animation but in Quicktime format. The option trick to quit on the first card forced everyone to notice the menubar was hidden, but it took a while for everyone to discover that Option-click on the "Next" button was what allowed you to leave the stack. Suggestions were made to click on the question mark parts and on the skull.

*Comment by Christine*: Glenn could teach us all a lot about animation. His stack had 2 examples of animation - Yorric on the front card and Glenn appearing beneath the clouds ("Hail Glenn", said Robert!)

*Stack* - "***Art and Music***"

This stack is presented to be used in either hub or linear fashion. The theme is images with a song. The songs have been expressed in visual form. Each song is the first verse and the chorus. The movies were constructed in Adobe Premier - the song was pasted in the sound track, them the scanned image laid across the picture track and the combination made into a Quicktime movie. Songs were recorded off CD or with a microphone in front of a stereo. They were compressed 6:1 and each resulting movie occupies around 1.5 Mb of memory. You could get the children to play a song then draw the image that they imagine goes with it. This type of program could be used as a classroom resource for varied music. Deborah made the comment it would be good to have some tracks without words - some children could draw images, but others could write words to the songs.

*Comments by Christine*: Gordon has one real problem - COPYRIGHT! He can't do this, but he could record the music produced by himself or students.

*Stack* - "***Our Pets***"

This is for really young children who haven't used a computer before. The stack opens with a great image of a cat, music which fades back as a voice over introduces the program, and instructions on how to progress to the next card. Some hand-written text with a voice over explains how wonderful pets are, whether common or unusual, then the next card shows some lovely images of pets. Sounds feature on the next card, then finally a movie and a farewell card. The features of this stack are the wonderful sounds - the narration, music and instructions. Joaney noted that it took her a whole day to produce the sound track, with a keyboard manually controlled for volume, and the narration notes. It was noted that SoundEdit Pro would allow you to add voice over music which could be faded away.

*Comments by Christine*: while the technology makes that type of thing easier, the real fun in the classroom would be to produce a sound track as Joaney had done - with a team of people.

*Stack* - "***USA Seasons***"

Lara was not sure what age group this stack is appropriate for. We all enjoyed it! The idea was to show us all something of what seasons are like for Lara back home in Massachusetts. The buttons are coloured to match the seasons, and once viewing a season, the buttons to progress are colour coded to the season to which you are heading. The movie was an excellent selection of footage for Quicktime - even though it was small (around 96 by 96 pixels), the action was great. The information on each season was interesting, with some unexpected facts: Summer - scratching mosquito bites; Autumn - leaf peeping; Winter - car accidents; Spring - marriages.

*Comment by Christine*: the music is beautifully matched to the images of winter, creating great atmosphere.

*Stack* - "***The Senses***"

This stack presents part of an evaluation of a unit of science on the senses. A flip-up book was used with the children, and images from this book have been scanned in. This stack covers the eyes, ears, tongue, nose, and a section on whole body senses.

*Comments by Christine*: What other type of resources would you add to this stack? This question brought the responses - more sounds, text, etc until Debbie made the point that it was an evaluation stack meant for Brian to read.

With this in mind , considering Debbie has all the classes on video, there is a wealth of material to use. The suggestion was made that key issues be asked as questions, with multiple responses from the children to show what the classes were really like.

*Stack* - "***Tennis and Technology***"

This stack presents a lot of information on tennis and the influence of technology. It has a help button throughout with an audio response. The buttons have been made standard colours (pink for next card in any series, and blue for the contents button). The position of buttons has been standardised to minimise mouse movement for the user. Where surfaces are discussed, the fields have been colour coordinated to the surface colour. Buttons on the main menu have linkages, so when you access one of these linked buttons you know what other sections you can access without returning to the main menu. Michael added to the content as he presented the stack, and kept mentioning what additional information he would present. It was obvious this stack was content driven by someone who related very well to the content.

*Comments by Christine*: This stack has presented the most information, in a non-linear fashion. To see this stack developing the cards all seemed jumbled. The addition of colour coordination pulled the whole structure together yesterday. Michael added then that he would consider an alternate image selection screen like Margaret's farmyard in future.

*Stack* - "***Julie***"

"This is really simple - any child could do this. This is just a file on me." (Julie). Julie showed a baby photo, we heard her voice, saw a video of young talent time, her favourite TV program when she was 10 years old, heard her ducks Bacon and Eggs (who have subsequently been brutally slaughtered), and met her husband Eric.

Julie put forth the idea that children could produce a portfolio about themselves, adding significant family members. This might be the sort of thing begun in kindergarten and added to over the years.

*Comment by Christine*: Remember as teachers to take plenty of photos of the children, shoot video whenever a special incident occurs and record sound files of your class members and special discussions as often as possible as a wonderful source of this kind of material for the children to use.

*Stack* - "***Learn the Guitar in Five Easy Steps***"

This stack shows you some chords for beginners, how to hold the guitar, parts of the guitar, some video footage of good guitarists, then presents some sheet music to allow you to use the chords you have learnt. Lara asked whether the chords shown were obvious to the user who is supposedly a novice.

*Comment by Christine*: What would you add to this to make it clearer for a user? Paul suggested a video clip of a guitarist placing their fingers on the strings, the strum and some voice overs.

Stack - "***A Visit to the Farmyard***"

This is presented as an interactive storybook. A music button on the first card sets the mood for the book. The next screen introduces the rooster who makes a wonderful noise (nice one, Margaret - you get the special effects award). Next card is an overview of the farmyard, with buttons beneath each creature to allow the user access to more information. There is a help button with a sound response advising the user to click on an animal in the picture to find out more about it. Margaret hoped to have a sound, image and movie on each of these cards, but did well with what she presented in the time. We saw the sheep (image and text),the horse (image and text), Geese (image and video - great scene), chooks: "The lengths you go to get the material is the fun part" (Margaret, referring to locking herself in the chook pen this morning to record the noises!), cows (image and text), dog (image and sound file) and piglets (image and video)

Stack - "***Maths Tutorial***"

This stack is a maths diagnostic test. You type in your name on the first screen - the teacher later uses this to analyse the problems you are having. Each card presents a maths addition problem of increasing difficulty. Five possible answers are scattered over the card. All incorrect answers provide feedback on the possible reason you made the mistake. The correct answer provides audio feedback, then moves you to the next card. The student learns as they go through the test, but can't quit. They must have a go at each question. When you get to the last card, a password is requested. If the student doesn't know this, the card shows only a button which when clicked plays a movie congratulating them on their achievement. If the teacher enters the correct password, a field and two extra buttons appear. One button allows you to print the contents of the field containing a record of the user and all the buttons they have clicked. The other button empties all fields holding this information throughout the stack.

*Comments by Christine*: What other sounds could you put as the feedback for a correct response? This brought a range of suggestions, from student voices to comments related to how many attempts the student made on a card. It was suggested the sound length should be shorter than the one used by Robert.

Stack - "***Welcome to the 60's***"

"This is tacky time folks" (Gavin). During this presentation we found out 3 members of this group of 14 students are colour blind! Gavin is, and mentioned he had to constantly ask others how things looked. This stack aims to create the mood of the 60s. The first screen is colourful to say the least and this is topped with fluorescent coloured buttons. A movie on this card provides a message of welcome. The next screen gives an image of a vehicle of the time. Gavin pointed out how he added the text as an additional

image over the background, bringing it in as transparent with the colour tools. A range of images of groups or individuals may be selected on the following card to hear some music of the 60s. Images of fashion follow in this 4 card stack.
*Comment by Christine*: The feature of this stack is the mood created by the music and images. If you are fortunate enough to have grown up in this era, all sorts of memories come flooding back with the music and fashions. This is a great way to use sound and images.

*Stack* - ***"The Gold and Glory Days"***

This is a linear information pack on the gold rush days in Australia. A sound button on the first card plays some music to set the mood. Shelley has included a "Stop Sound" button to allow the user to stop the music whenever they wish. Moving to the next card ... "It's a lot of text and sound" (Shelley).Shelley has provided a "More" button to allow the user to read more text if they wish, or they are given the option of listening to a voice-over. To break up reading, the next screen is a beautiful full-screen image with a sound button to hear about features within the image. An image, open movie file and text adorn the following screen. The movie file is open, but the user has to click on the controller to start the movie. The final card is another full-screen image and voice over. Comments were made that it would be great to see aspects of the image hilite as they were referred to. Shelley said it would be good to add information about lambing flats, the Chinese, lifestyle, homes and diggings.

*Stack* - ***"Welcome to Parliament House"***

The parliament pack used by Veronica recently was a 1987 version which did not have the new parliament house in it. The aim of this stack was to complement the pack with some interesting information on the new parliament house. A small introductory video is placed in the top right corner of the first screen, which has a full-screen image of the new parliament house. The next card incorporates an image, sound file, stop sound button and video on the theme of history of the house. Card 3 moves on to show a map of parliament house next to an image of what the buildings look like, plus a voice-over. The final 2 screens show the Senate and House of Representatives as large images covered with numbers, and a code down the right to annotate the numbered image. The screen design in this stack is excellent. Veronica has a great sense of what resources to combine and where to place them on the screen.

## Appendix N - Class Process—EDUM 212 Class

*Class 1* : Christine stepped through the Agenda for Initial Discussions, which covered student expectations for software expertise, quality of final product, presentation of projects and teacher support. Assessment was negotiated for the major project (80%), the animation (10%) and lesson preparation tasks (10%). Students voiced project ideas to the video camera, then moved to machines to look through the HyperCard Support stack. Christine demonstrated a range of scripting features of HyperCard.

*Class 2* : The Course Outline was discussed. Christine asked students to think about user tasks in their programs. Gavin video recorded his ideas. Lara digitised video, while Christine showed the group the MC stack and discussed the concept of showing and hiding different objects, placing scripts on different levels, and the logical flow of script. The "Diary" stack with its card generating button was shown. Students worked independently—digitising video, scanning images, trialing scripting, and recording diary entries.

*Class 3* : Christine discussed mid-week scripting issues. Students then worked independently. Michael brainstormed ideas for his program while Christine entered these in "Themes". Michael liked the ease of card generation, ease of adding resources, the resource list, the notebook and facility to save to disk, all of which were used in "Themes". Christine added the notepad and media menu to Michael's stack. Other students worked on scripting and scanning.

*Class 4* : The topics Resources, Programming, Issues to Deal with, Aims of the Project, and Structures of Projects were discussed with the group, and answers noted on butcher's paper. Christine demonstrated the script for playing movies, how to add a menu, the "ask" and "answer" commands and wrote a script for generating a card which the user named. The stack scripts were exported and opened in Word 5.1 to show how a script was laid out. The stack and its export document were placed on the server for everyone to access. The group were really keen to begin scripting. Diary entries were video recorded by Glenn, who described his new idea, Gavin, Michael, Joaney, Lara and Christine.

*Class 5* : Christine organised interview times with students, discussed then demonstrated scripting tips in the stack "New Media & ShowList". The Showlist function, the new media menu, and sort and printout facility from numerous fields were demonstrated, before students moved to machines and began work on their stacks. Christine added the new media menu to Lara's stack . Joaney, Glenn, Gavin and Michael worked quietly up the other end of the lab. At 4.10

pm student presentations of their work were video recorded, to capture other comments. The order was Lara, Joaney, Glenn, Michael and Gavin, who finished at 5.40 pm!

*Class 6* : Christine demonstrated scripting issues then Glenn took over the mouse with the CD "Planetary Taxi". Students were critical of interface elements. Joaney worked on quietly. Glenn planned his lessons with the students and shared his lesson plans and "paperwork". Gavin scripted and did not ask for any help. Lara had scripting problems and began a HyperCard stack for another assignment. Christine and Glenn discussed hierarchical naming protocol with Michael. A recording mechanism was then developed for Michael's stack.

*Class 7* : The group discussion was video recorded, then everyone settled to their own work. Glenn was happy with programming progress. Joaney looked through the journals and scanned selected images. She wants to do her more complex scripting later. Michael needed some scripting help to fix up his menus in the proper stack and decide the interface for generating more cards. He is still concerned the constructor won't be able to visualise the sequence, and wants to develop a visual representation of the cards. Lara worked on some scripting, requesting help only when she was stuck. Lara was really pleased that today she had tried to fix things herself, and made some great progress in understanding HyperTalk. Gavin worked on scripting, fussing with menus, saying he wanted to delete most of the HyperCard menus in his stack. We tested the effects of this together. Gavin is visiting Stuart at the Field Study Centre next Tuesday. Christine suggested he take the video camera to shoot some Zooming shots for animation work for his program.

*Class 8* : The AddMotion tutorial dominated proceedings - Christine read through the document with students, discussing the educational value of animation. Students were then asked to view the "Principles of Animation" stack before discussion of the menu explanations in the handout. Students returned to their computers, and Christine verbally walked them through the first two lessons of the AddMotion II tutorial in the AddMotion Manual, which was black and white. By 3.30 pm, students began a new animation of their own, working in colour. Glenn created Charlie Brown, who was watching a kite fly by when a kite-eating tree disposed of the kite with a belch! Later the tree spat out the tassel. Michael kept saying he was not creative and artistic. All other students enjoyed the exercise.

*Class 9* : Gavin was at the Field Study Centre. Christine explained there were new PowerMacs in the lab, then discussed the task for next week. Discussion followed on possible computer lessons. All students resumed work on their projects. Joaney worked on her stack, and scanned some more images she had found in another book. Lara worked on her scripting, and managed to fix all the scripting needs she has had. Christine then helped Lara flip the show/hide button back to "show" when a movie finished playing, using the closeMovie message. Michael was dejected as his scripting wasn't working. He had tested things in other stacks, but not transferred all parts to the real stack. Christine fixed the problems quickly. The recording was working again, and Michael began work on the template section. Gavin returned from the Field Centre. Christine discussed the task for next week then left Gavin to digitise video and scan images. Glenn scanned in the class image of the forest, but changed it considerably. He asked about some scripting associated with the Color Tools stack and sound resources.

*Class 10*: The group discussed the task, to begin at 3.00 pm, then students headed to the computers. Glenn said he had to ride home for something, but had all his work done. Christine prepared the display machine and video. Lara typed up her lesson plan. Joaney worked on an animation. Gavin digitised video, then Glenn set up the batch to process for Gavin. Michael worked on his stack. Lara presented Christine with a birthday present, and Glenn produced a cake! What an incredible group of kids! Christine and Joaney recorded her large sound file for the radio in her 60s house. Task presentations began just after 3 pm. The presentation order was Glenn , Lara , Joaney , Michael and Gavin.

*Class 11* : Matthew was not available for technical support today, and the recent 10 day workshop had caused considerable re-arrangement of machines. There was no video facility linked up for digitising in the lab. Glenn demonstrated his animation of the state boundary changes in Australia. Michael seemed very tired and distant today. Gavin arrived a little late. We tried AddMotion on the PowerMacs and it kept crashing. The stack on the server was corrupt. Students loaded each machine they used with AddMotion off the disks. Glenn worked on his documentation for a while, then experimented with AddMotion. Joaney scanned some images, then after attempting unsuccessfully to digitise a movie, organised all her work on the one machine. Lara tried to work on her animation, but AddMotion kept giving her problems. Michael played with his stack- images would work then disappear. He began to add images to his world peace scenario. Gavin was also unsuccessful with video digitising. He mentioned that he was progressing well at home on his machine, with its 20 Mb of RAM!

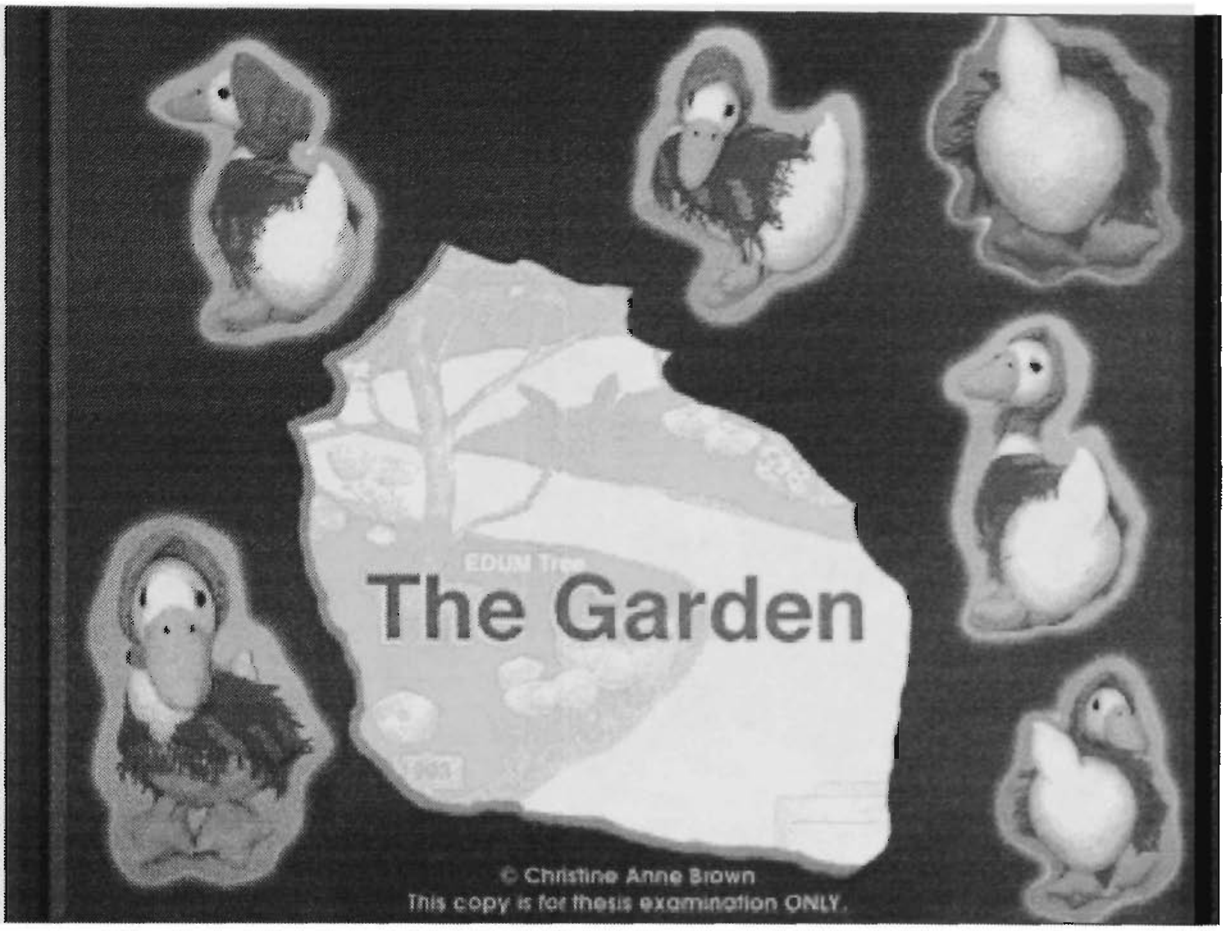
*Class 12* : Some postgraduate students sat through class today. Lara, Gavin, Michael and Glenn had been in the lab either all morning or most of it. Joaney had just arrived. Matthew attempted to demonstrate the new video digitising procedure, but it kept crashing the machine. Christine then set the video camera up and animations were presented in the following order: Michael (used AddMotion for production), Joaney (used AddMotion, PhotoShop, ResEdit, QuickFlix), Lara (used AddMotion, QuickFlix), Glenn (used another paint program, then Convert to Movie) and Gavin (used AddMotion). After yet another week of software mishaps, and much frustration, it was time to pack up. Christine mentioned she would not be around the next week.

*Class 13* : Class began promptly with a discussion about the needs of resource production in the next week—specifically movie production. Joaney, Lara, Michael and Gavin needed scripting help. Christine would be in the lab on Saturday from 10 am. All except Michael would be in. The presentation next week would be in the lab. The group discussed evaluation, and collaboratively defined the four points the peers were using to mark each other. Students worked individually. Joaney batch processed her movies, and turned attention to her stack. Glenn experimented with Convert-to-Movie. Gavin scanned in many more images. Michael wanted scripting help, and presented a list of things he wanted to achieve. We removed a menu which kept appearing, and scripted to save the scenario path to disk. Other issues were too large to dominate teacher attention in class. Lara worked on her scripting. She wanted the screens to reveal a word once all the resources had been accessed. Christine developed a system with a hidden background field, and additional code in the media buttons. Lara was surprised at the simplicity.

*Class 14* : Lara and Gavin were working hard. Christine generated movie buttons to play Joaney's radio and TV and installed the Movie XCMD into Joaney's stack. Joaney then linked 5 other stacks she had made. Michael, happy but tired due to his recent illness, sat down at his regular machine to work on his stack. Lara made some last minute changes to her stack before copying it to the external hard drive. Christine set up the video camera and the monitor, so we would get the best video quality possible in the circumstances. Gavin's stack and resources were copied across to the 640 Mb drive while the group sat around the table, discussing the presentation, and the great qualities of all the team members. We looked through the evaluation sheet again, then moved to the best locations to view the presentations of Joaney, Gavin, Michael, Lara and Glenn with a variable audience of up to 24 people. Joaney presented Christine with a card and present with warm thanks and a huge smile.

## *Map : The Garden Gate*

This is the opening screen of *The Garden*. The ducks are your helpers. If you select the hole in the gatepost, you may enter the garden directly.




### *Design Rationale :*

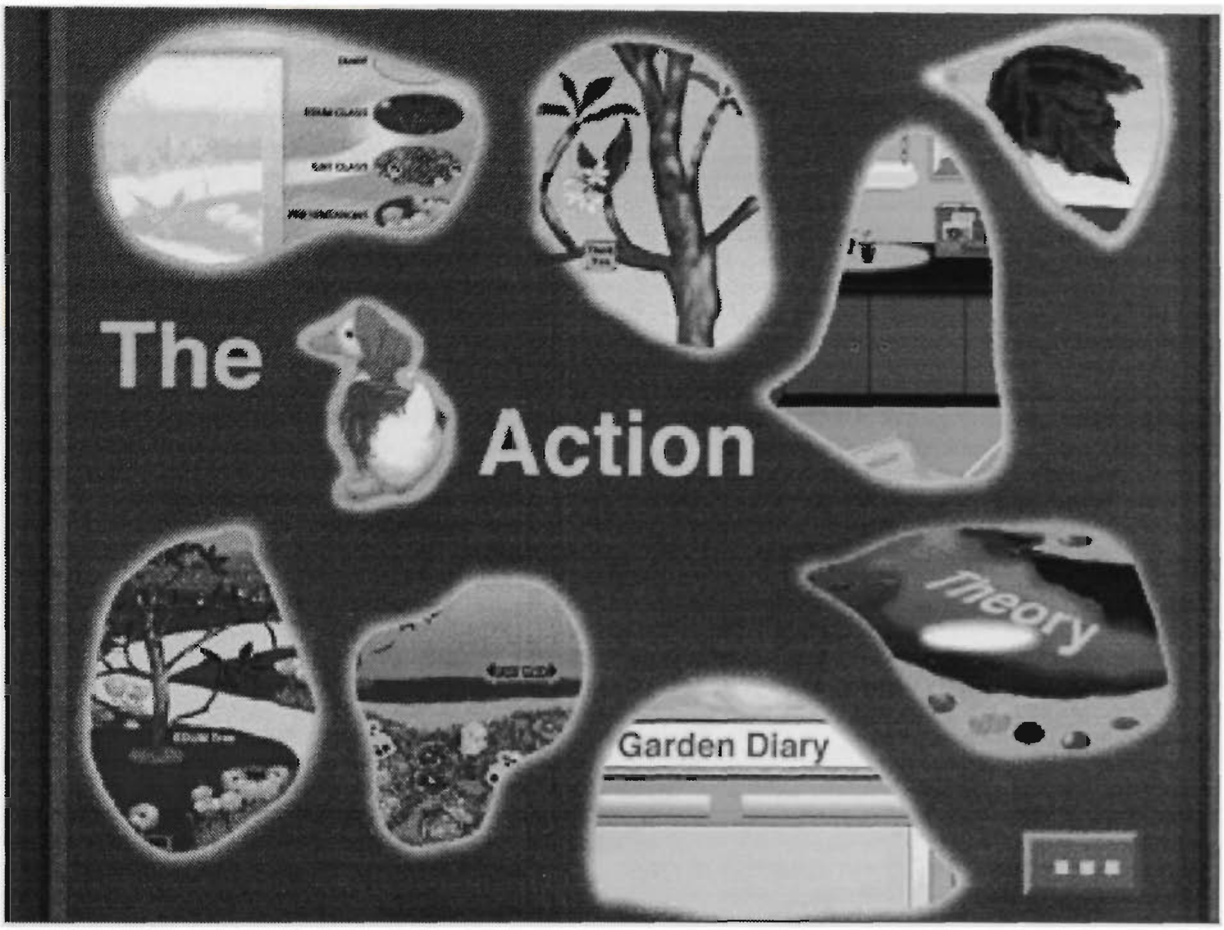
Selection of any of the ducks takes you to "The Action"— the walk-through help movies. The hole allows you to sneak straight into the garden and explore unassisted. The duck symbolises The University of Wollongong. Anyone who has visited the campus will testify to the fact that these creatures are powerful enough to stop traffic! The knitted example used as the model for the assistant was the personal creation of the researcher's mother-in-law. The likeness to Jememiah Puddle Duck is unmistakable, but not intentional, and carries no connotation of that character. Since this CD is only for researcher use and examiner viewing, there is no breach of copyright law.

### *Navigation Options :*

You enter the "PhD Walk" within the garden through the hole in the gate. If you first choose to view the help movies, you are returned to this screen to enter the garden through the hole.

## *Map : Help Screen— The Action*

Selection of the duck from anywhere in *The Garden* brings you to the help screen. To gain a quick overview of functionality within any section, select the graphic to view a descriptive walk-through movie.




### *Design Rationale :*

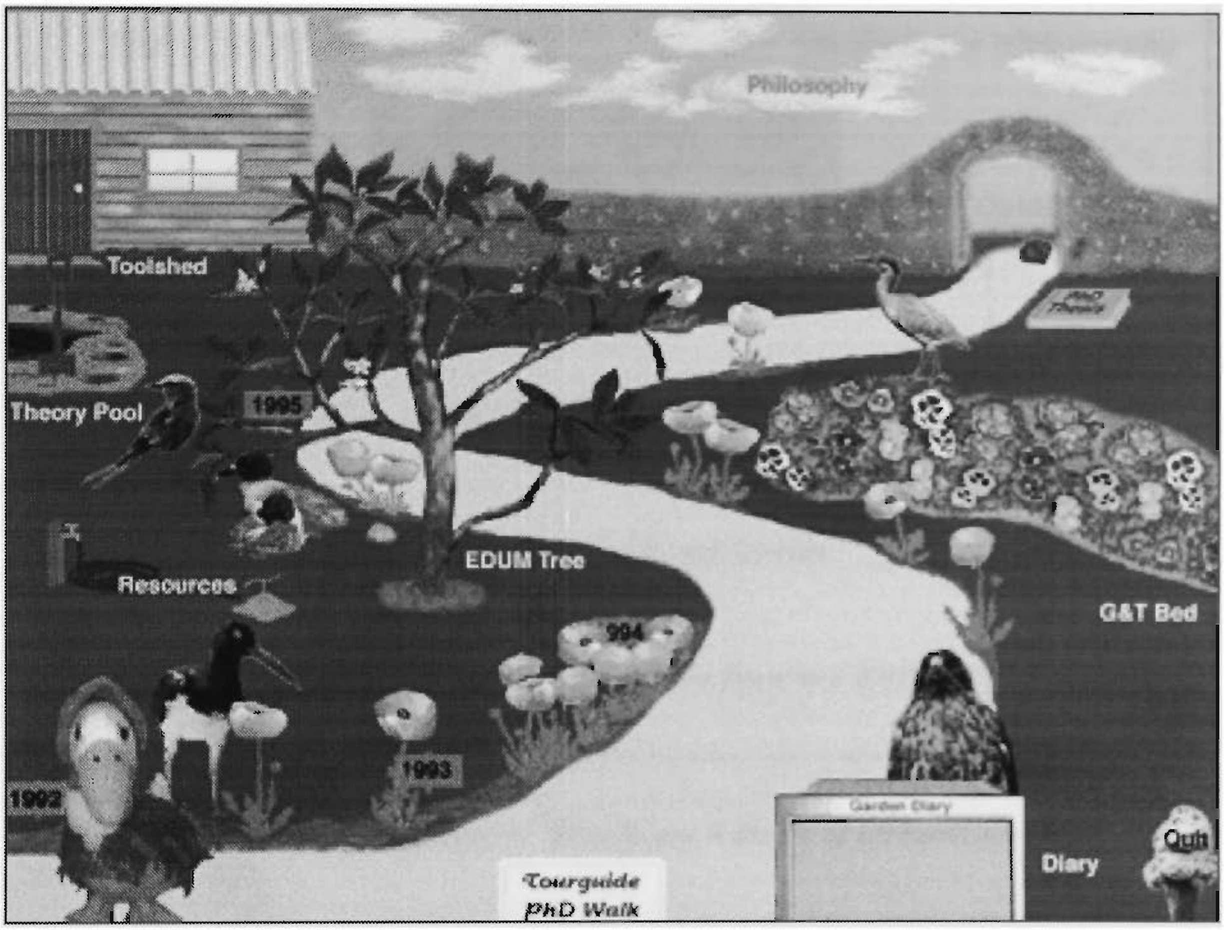
Help is presented for each key visual space within *The Garden* This common help site allows you to overview program functionality. A number of sites, for example the EDUM Tree, G&T Bed, and the Toolshed, lead to further levels of content or link with other software. Any unusual functionality is described within the help movie.

### *Navigation Options :*

Selection of any graphic plays the help movie. To return to the site where you requested help, select the "powerplug" ('...') in the lower right corner.

## *Map : The PhD Walk*

The "PhD Walk" presents the global view of this study. All major themes are represented visually as objects within the garden. The case studies (EDUM Tree and G&T Bed), gardener's diary, toolshed, resource sprinkler and theory pool each expand into another section of *The Garden.* Less extensive aspects of the "PhD Walk" are the presentations, signposts, philosophy clouds, autumn leaves and project birds.




### *Design Rationale :*

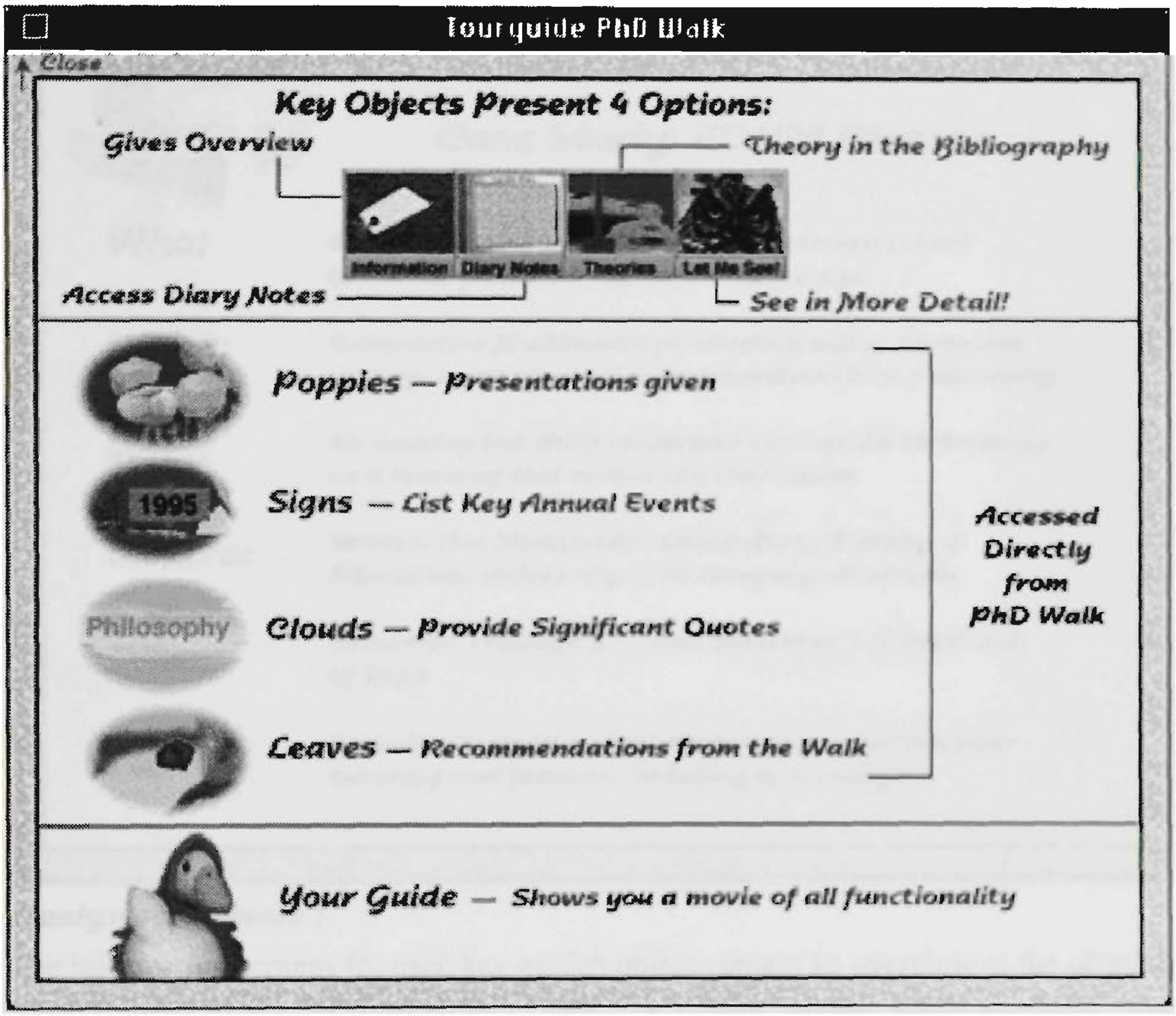
When the key themes of the study were identified in 1994, they translated visually into garden objects. The time period of 1993, while not officially part of the researcher's PhD candidature, is represented in the "PhD Walk" as a vital source of researcher experience with presentations and project work.

### *Navigation Options :*

The 'Tourguide PhD Walk' in the lower middle foreground presents a quick overview of the key objects within this screen. Selection of any of these key objects presents a palette of 4 options— 1- read some overview information, 2 - access the relevant theory theme, 3 - read diary notes on that object theme, or 4 - see the object closeup. Less major objects are directly accessed. All permit you to return to the "PhD Walk" to pursue other pathways.

## Map : Tourguide for the PhD Walk

This window opens when you select 'Tourguide PhD Walk'. It details the different aspects of the key garden objects you can access via the palette (shown in more detail below), and describes the objects which are visited directly from the "PhD Walk":

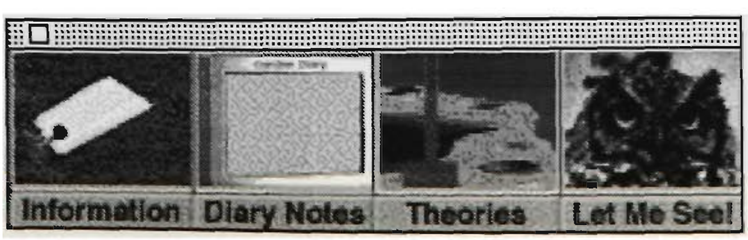



### Design Rationale :

This was designed as a simple help window in terms of navigation options from the "PhD Walk". The duck is your guide to functionality, via walkthrough movies.

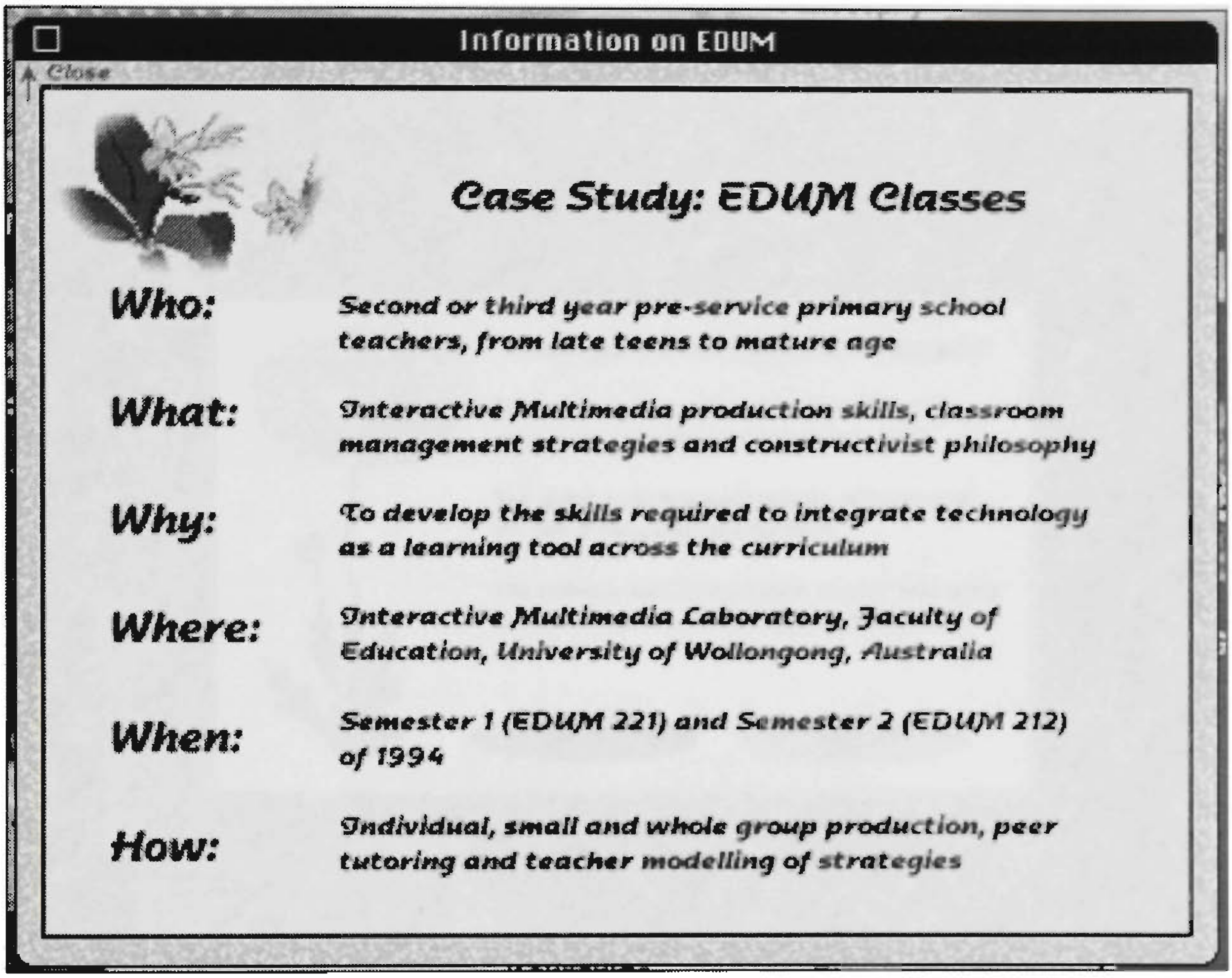
### Navigation Options :

The window 'Tourguide PhD Walk' must be closed to access other features within the "PhD Walk". The palette is shown in more detail below:



## *Map : Information on a Key Garden Object*

This particular window is opened by selecting the EDUM Tree along the "PhD Walk", then the information option on the associated palette:




### *Design Rationale :*

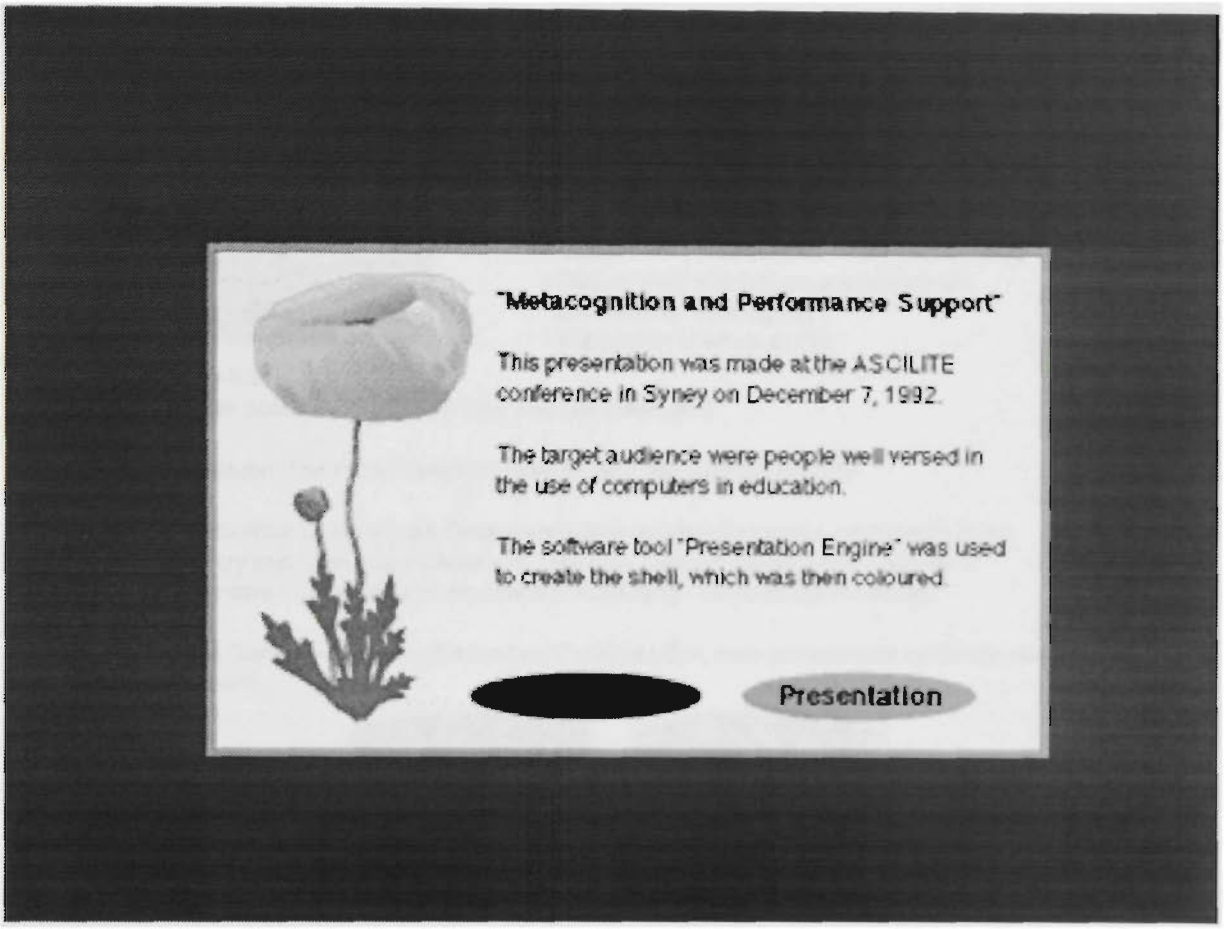
The information screens for each key garden object contain an overview of the object in simple terms of the interrogatives— who, what, why, where, when and how. This allows you to assess whether you wish to view the object in more detail. For the researcher, the creation of these information screens was important to summarise the nature of each garden object and convey the functional perspective of the researcher in that aspect of the overall study.

### *Navigation Options :*

The window 'Information on EDUM' must be closed to access other features within the "PhD Walk". A quick view of all information windows provides you with a summary of the main perspectives taken by the researcher within *The Garden*.

## *Map : Presentation Overview*

The poppies along the pathway of the "PhD Walk" represent a series of presentations which the researcher has given to varied target groups. These presentations have pushed the researcher to express conceptual understanding at different stages in the study.




### *Design Rationale :*

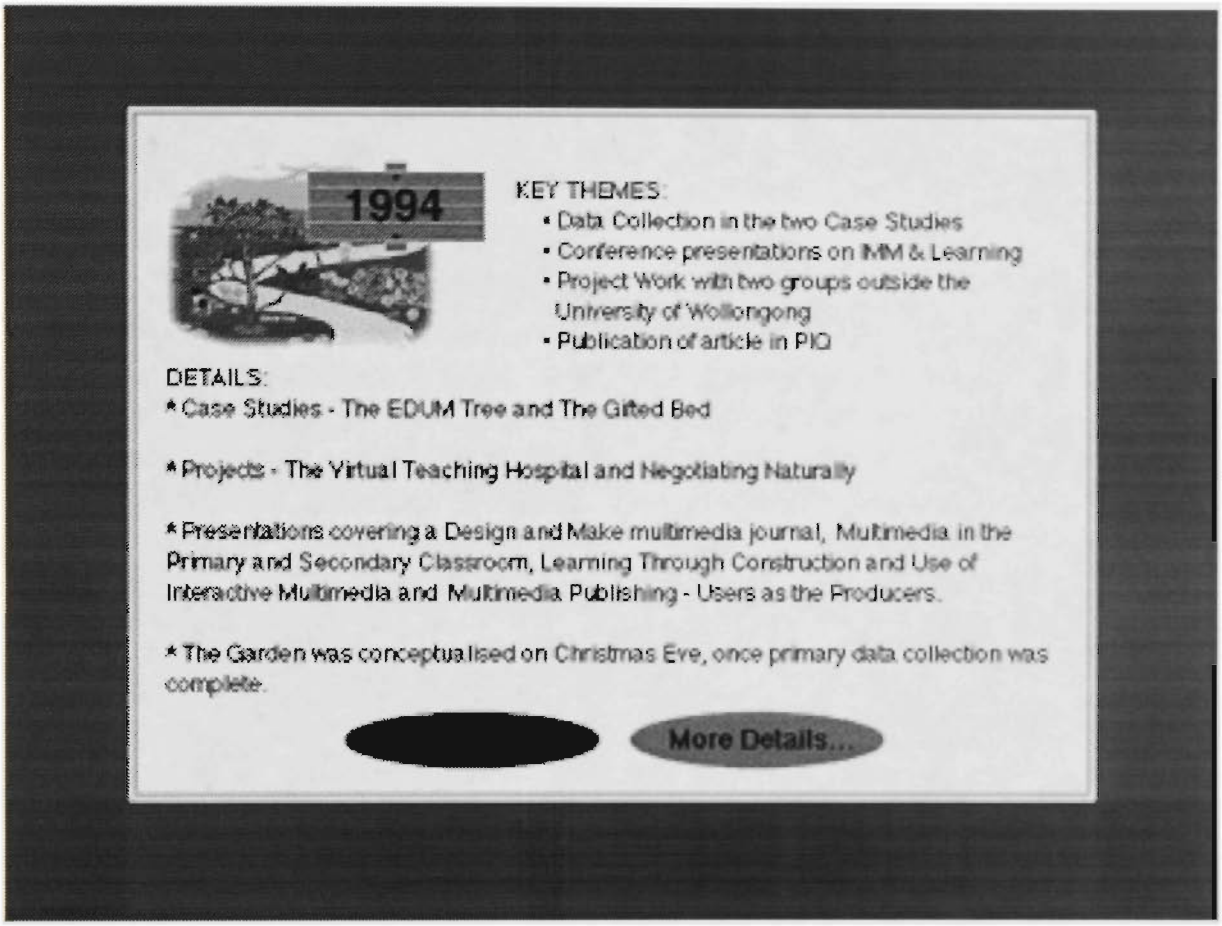
Within the garden metaphor, the outputs are either primary—plant growth, or secondary— project birds which have fed on other garden products. The poppies along the path are researcher outputs, presented within an accurate time frame of yearly signposts. The presentation overview screen above gives a brief description of the presentation topic and target audience.

### *Navigation Options :*

You may either return to "PhD Walk", perhaps to preview another presentation, or choose to view the 'Presentation' you have selected.

## *Map : Annual Signpost*

The signposts along the pathway of the "PhD Walk" represent a series of markers for the beginning of each twelve month period of the study. They each present an overview of the key aspects of that time period across all garden themes.




### *Design Rationale :*

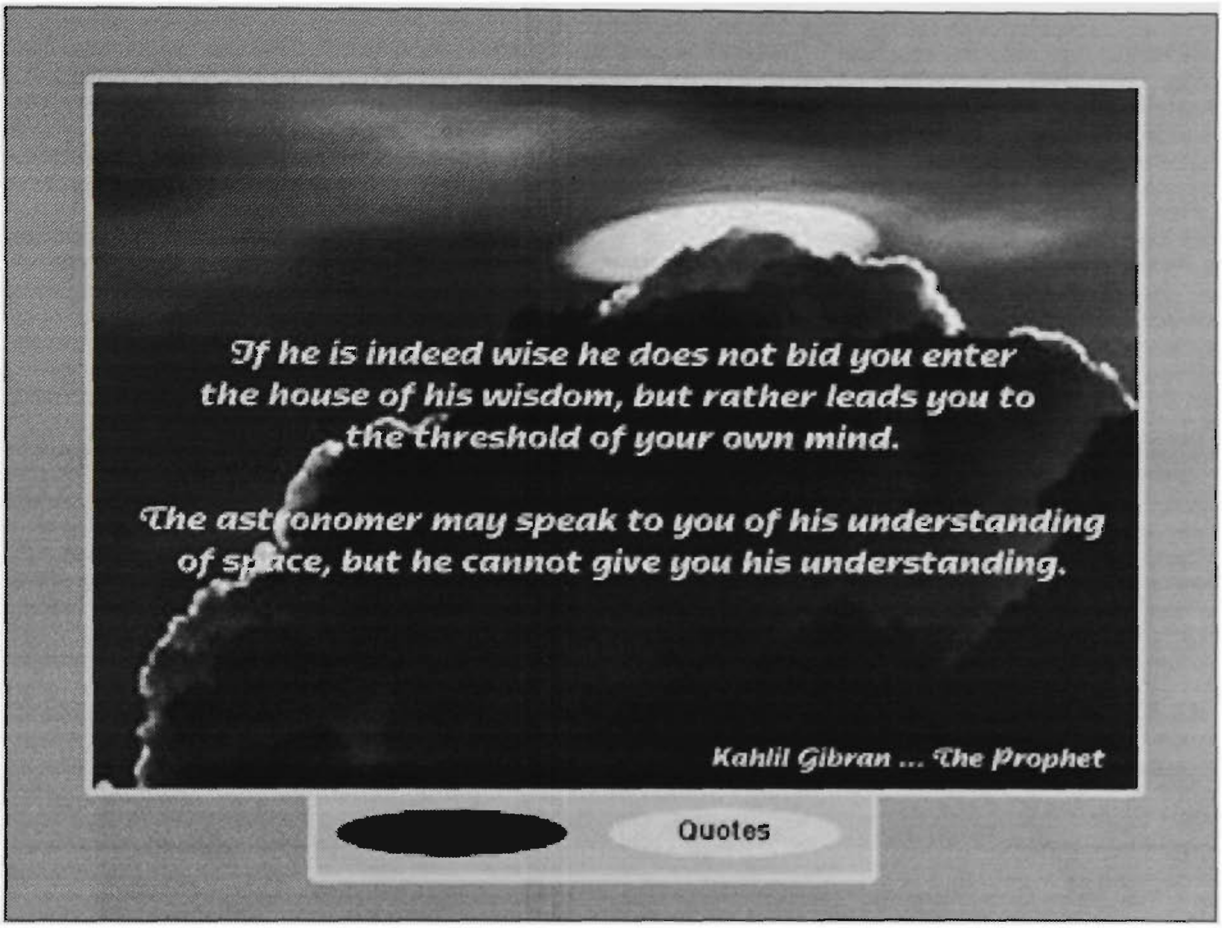
These signposts were initially ornamental time markers. In early formative evaluation of the interface, several users attempted to click on them. The researcher realised they could be used to summarise the key events of each year.This process was very powerful as a mechanism to capture the study in a few screens, and enable the researcher to express a complex network of themes relatively simply. There was no equivalent framework within the thesis for such a summary of key events, yet this process of event identification and listing was a powerful learning strategy.

### *Navigation Options :*

You may either return to "PhD Walk", perhaps to preview another signpost, or choose to view 'More Details...' for the year you have chosen.

## *Map : The Philosophy Clouds*

The philosophy clouds present a range of quotes from authors who have left a deep impression on the researcher. They cover such issues as philosophy, teaching and learning.




### *Design Rationale :*

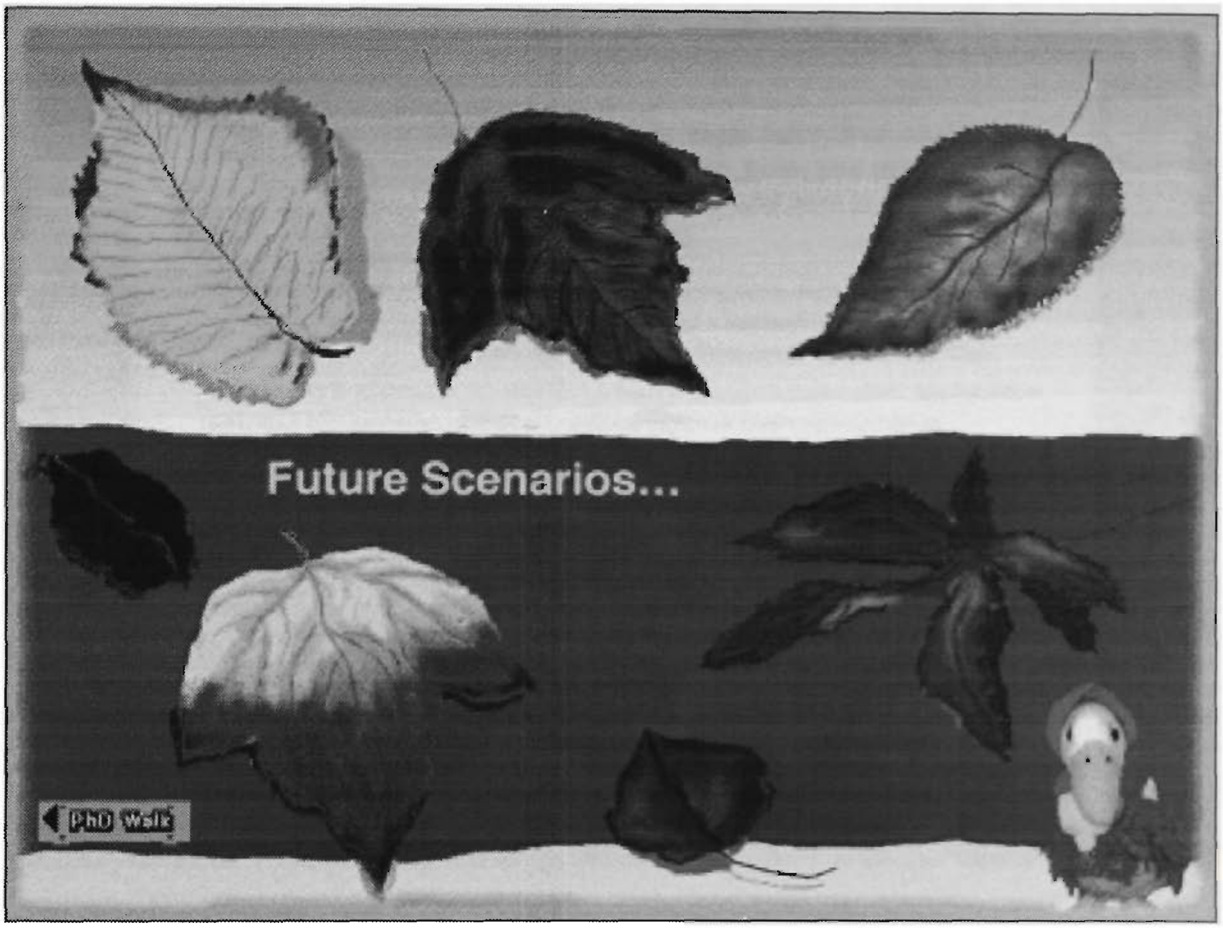
Within the garden metaphor, the inputs are sun, soil and water. The sun is regarded by the researcher as the input which has the most impact on the overall "climate" of the garden. It is therefore seen as the ideal point of access to quotes on some of the deeper issues of the study. Clouds are the natural backdrop for these quotes, varying in their nature and density, and thus altering the amount of sunlight in the garden. For the researcher, this was the place in *The Garden* to contemplate the deeper purpose of the study— the place to retreat and collect thoughts.

### *Navigation Options :*

You may either return to “PhD Walk”, or choose to view more of the 'Quotes'.

## Map : Future Scenarios

The leaves which fall at the change of season carry with them nutrients for further growth in the garden. These leaves each present a key recommendation from the researcher's experience constructing *The Garden.*




### Design Rationale :

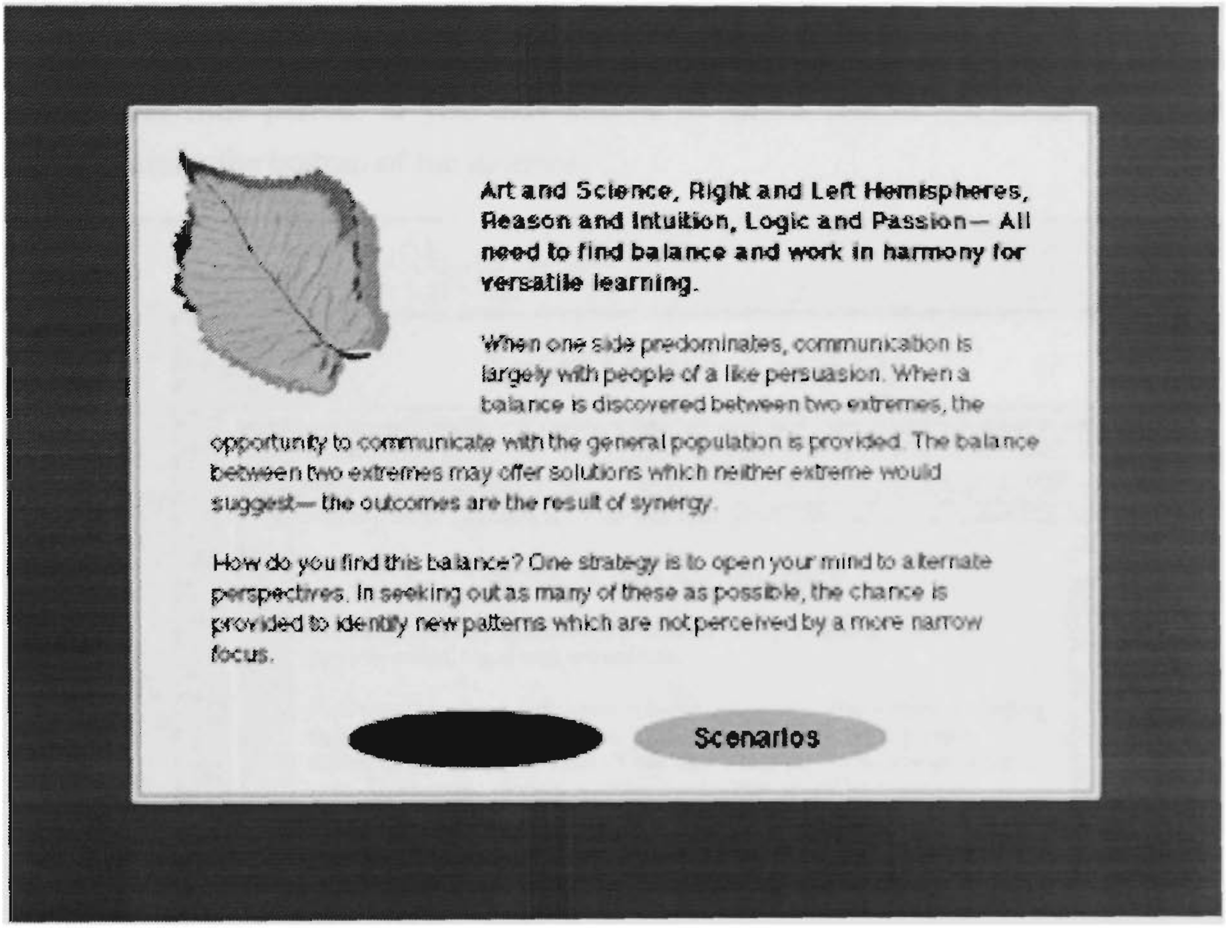
The autumn tones of the leaves are in sharp contrast with the summer tones of the "PhD Walk". These deciduous leaves will pass on their nutrients to be re-cycled within the following growth period of *The Garden*, or within another landscape altogether. Their colours are intense but short lived. Like research recommendations, they have an ideal viewing time. These recommendations do not match those in the thesis. Instead, they reflect the more personal views of the researcher captured within the landscape of *The Garden* An example is presented in the following map.

### Navigation Options :

You may either return to the "PhD Walk", or select one of the leaves to view a recommendation made by the researcher.

## *Map : Recommendation for the Future*

Each leaf presents a key recommendation made by the researcher following the rich experience of constructing *The Garden*.




### *Design Rationale :*

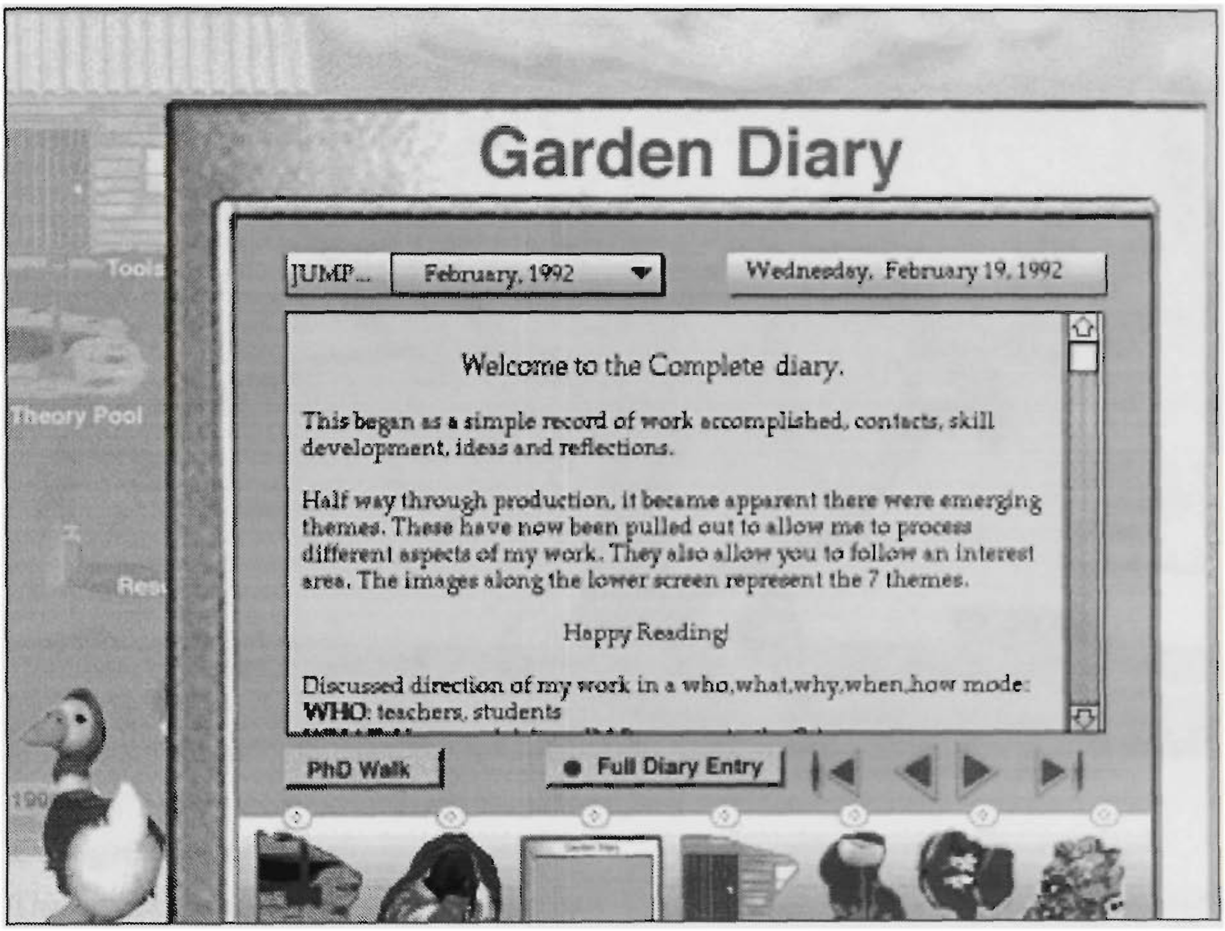
The varied shapes and colours of the leaves indicate the diversity of recommendations and the range of issues within *The Garden*.

### *Navigation Options :*

You may either return to the "PhD Walk", or select another 'Scenario' recommended by the researcher.

## Map : The Gardener's Diary

Selection of the Garden Diary in the "PhD Walk", then the palette option to "Let Me See", opens the Gardener's Diary. Selection of the 'Diary Notes' option in the palette of any key object within the "PhD Walk" will open the diary with the appropriate theme selected. Within this diary, you can choose to read daily notes recorded over a four and a half year time period, or you may choose to follow one of the themes presented visually along the bottom of the monitor.




### *Design Rationale :*

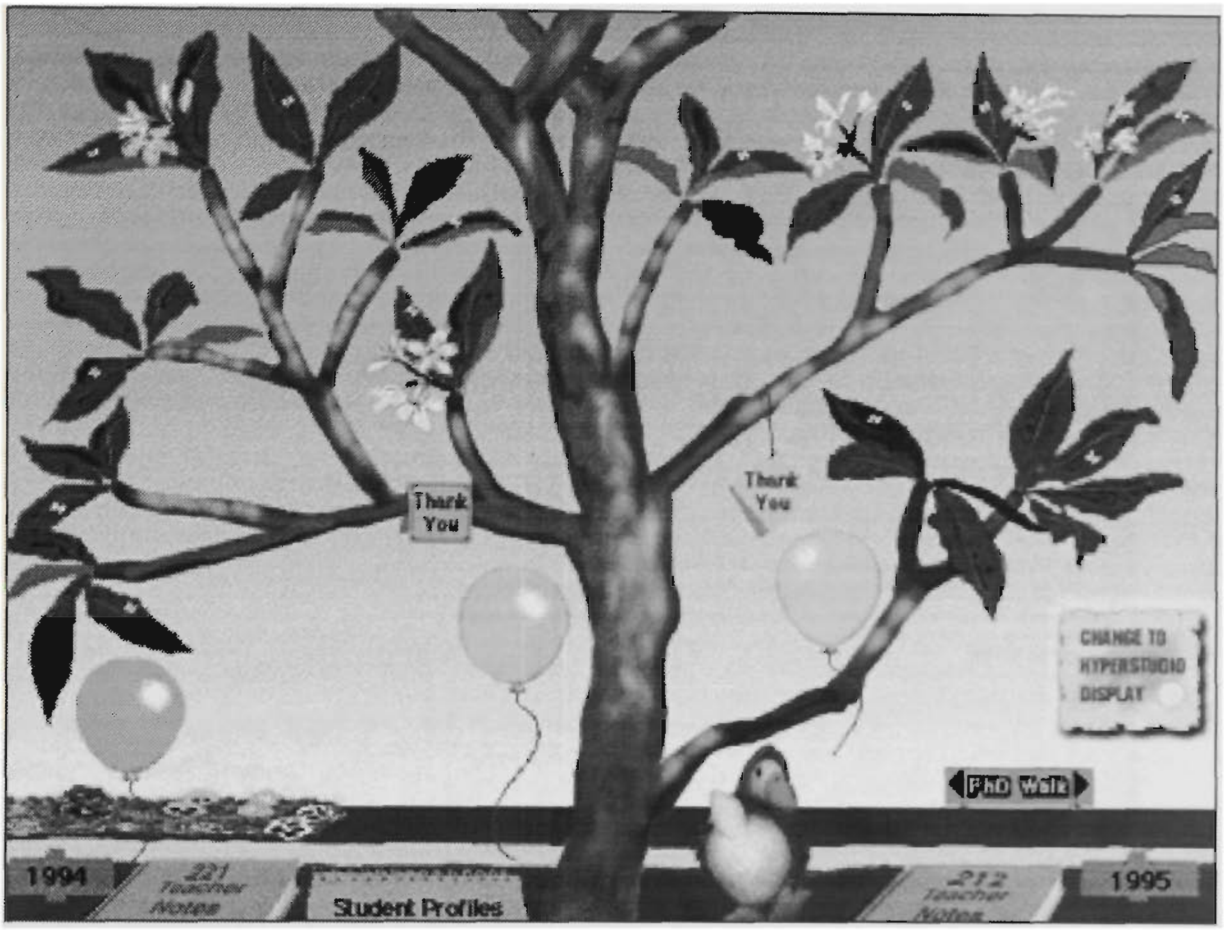
When the key themes of the study were identified in 1994, they translated visually into garden objects. For the researcher, it was much easier to work with the visual representation of the theme— a more global and versatile "label", than to try and use a key word for identification. Each theme could therefore incorporate a flexible number of sub-themes .

### *Navigation Options :*

The navigation arrows allow you to progress through the diary entries. Selection of a theme is indicated by the red indicator light above a theme image. When a theme is selected, the arrows move you to the next relevant entry for that theme. Selection of the 'PhD Walk' button returns you to the "PhD Walk".

## *Map : The EDUM Tree*

Selection of the EDUM Tree in the "PhD Walk", then the palette option to "Let Me See", permits you to access a range of student project work, thank you cards. student and teacher thoughts, researcher notes on all classes, and student profiles.




### *Design Rationale :*

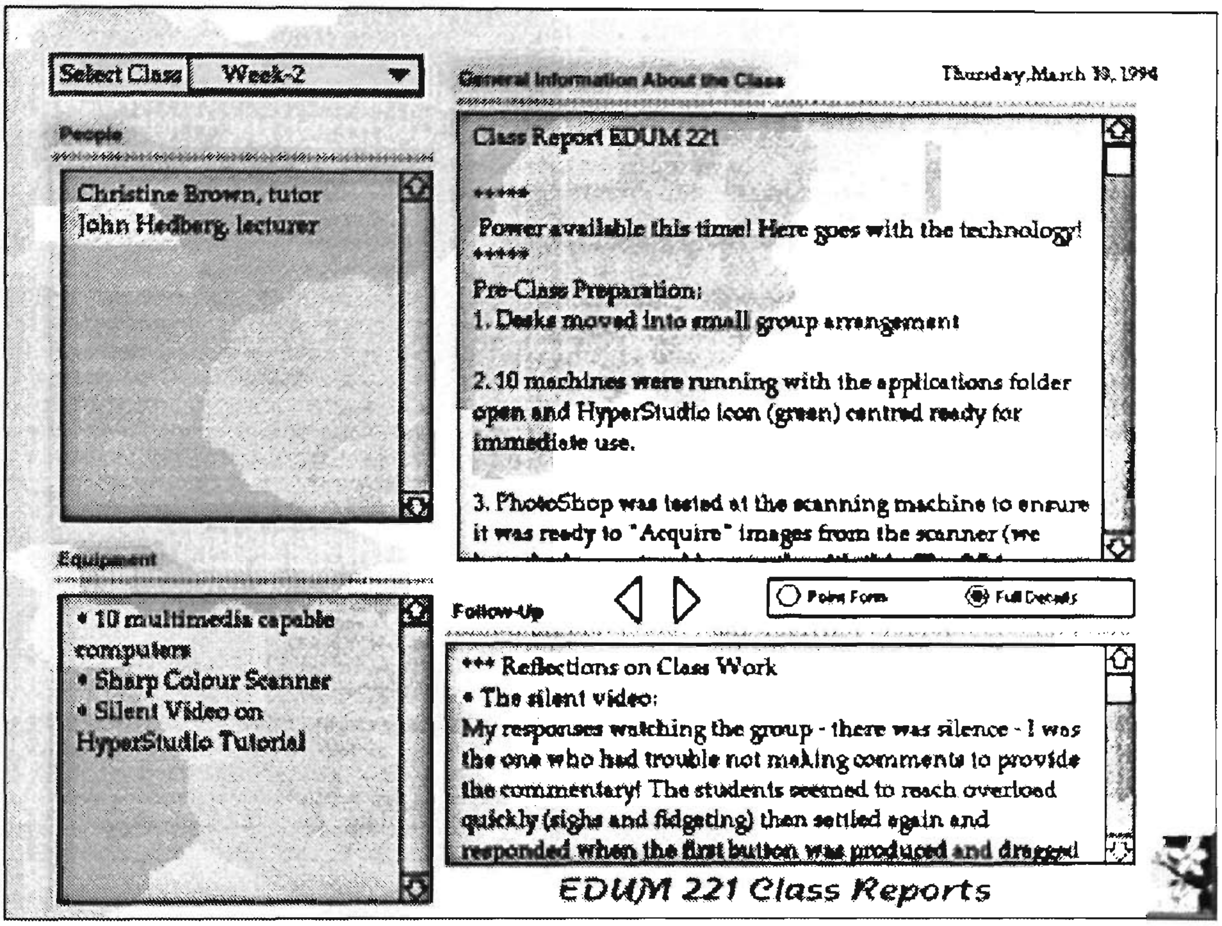
The signposts along the pathway indicate the time frame— EDUM 221 teacher notes are in the left foreground of the tree; EDUM 212 teacher notes are in the right foreground of the tree. Balloons hold student thoughts shared through questionnaires or interviews. Each branch represents the work of one student. All leaves with white moths indicate HyperStudio® projects, while all leaves with red ladybirds indicate HyperCard® projects. The five branches with flowers show the work of students who completed both EDUM 221 and 212. Selection of the flowers shows a graphic from the major project work.

### *Navigation Options :*

Selection of any leaf will open the attached project work. To switch to see HyperStudio® projects, choose "Change to HyperStudio Display". The signpost will return you to the "PhD Walk". Selection of the G&T bed will take you straight to the other case study.

## Map : EDUM Class Notes

Selection of the book 'Teacher Notes' in the left (EDUM 221) or right (EDUM 212) foreground of the EDUM Tree permits you to access the detailed weekly class notes kept by the researcher. These record the people present, the equipment used, the general flow of the class, and the follow-up work required.




### *Design Rationale :*

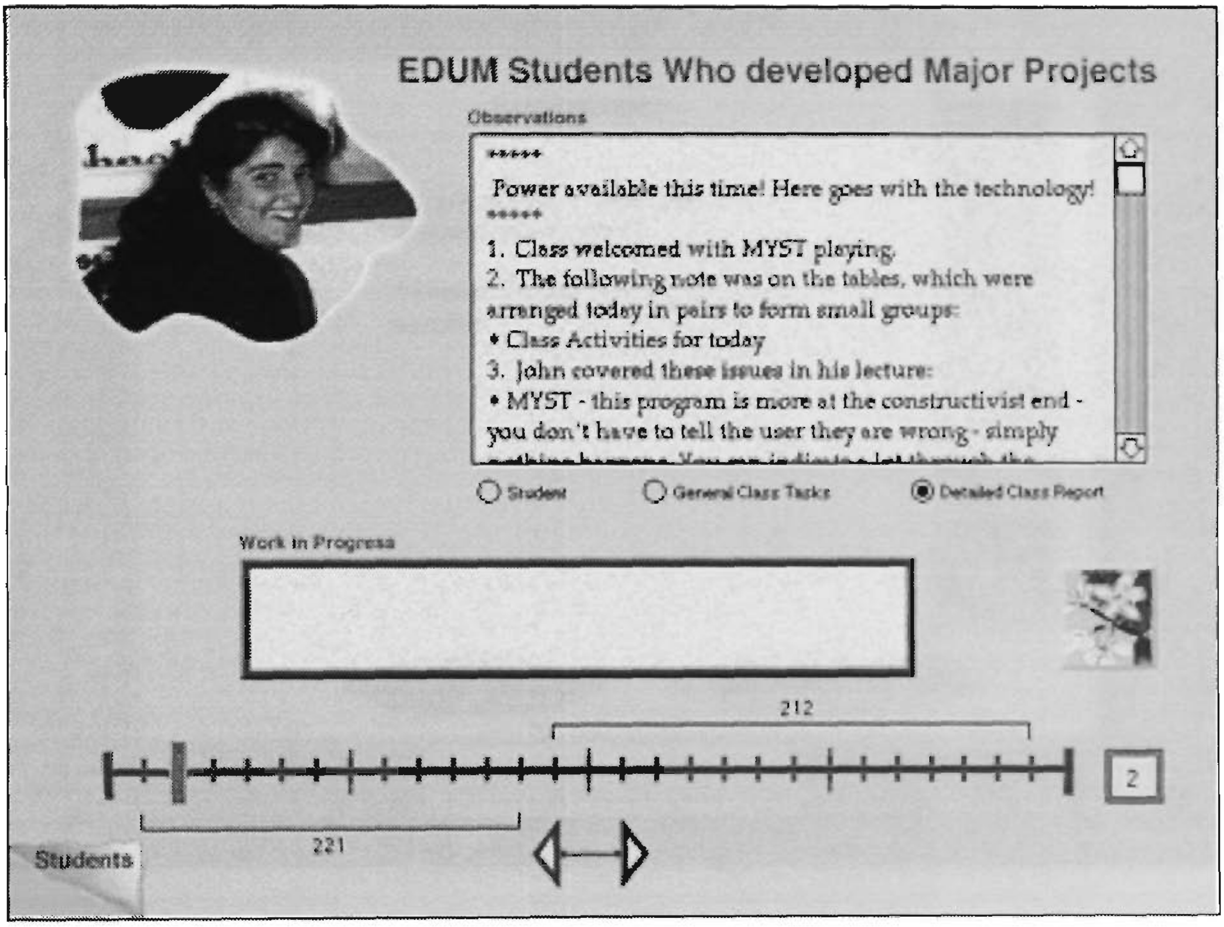
The "Teacher Notes" HyperCard® stacks were functional performance support tools for the researcher. They standardised data recording over a lengthy period of time for consistency within and across case studies. The interface was simple and quick to design. For data processing, the researcher added the facility to view class and follow-up notes in point form, rather than full detail. The summarising process which followed permitted the researcher to regain a very accurate sense of the classes for case analysis in the thesis.

### *Navigation Options :*

You may select a class from the pull-down menu at the top left, or step through each class in sequence using the arrows. Data may be read in 'Point Form' or 'Full Details' via selection of one of the radio buttons. The EDUM Tree flower in the lower right corner will return you to the EDUM Tree to browse further case details.

## Map : EDUM Profiles

Selection of the 'Student Profiles' folder beneath the left side of the EDUM Tree permits you to follow the progress of the five students who completed both EDUM 221 and EDUM 212. Class observations are presented for the student, the general class tasks, and the detailed class notes. The 'Work in Progress' panel may contain access points to images, movies or sound files as appropriate.




### Design Rationale :

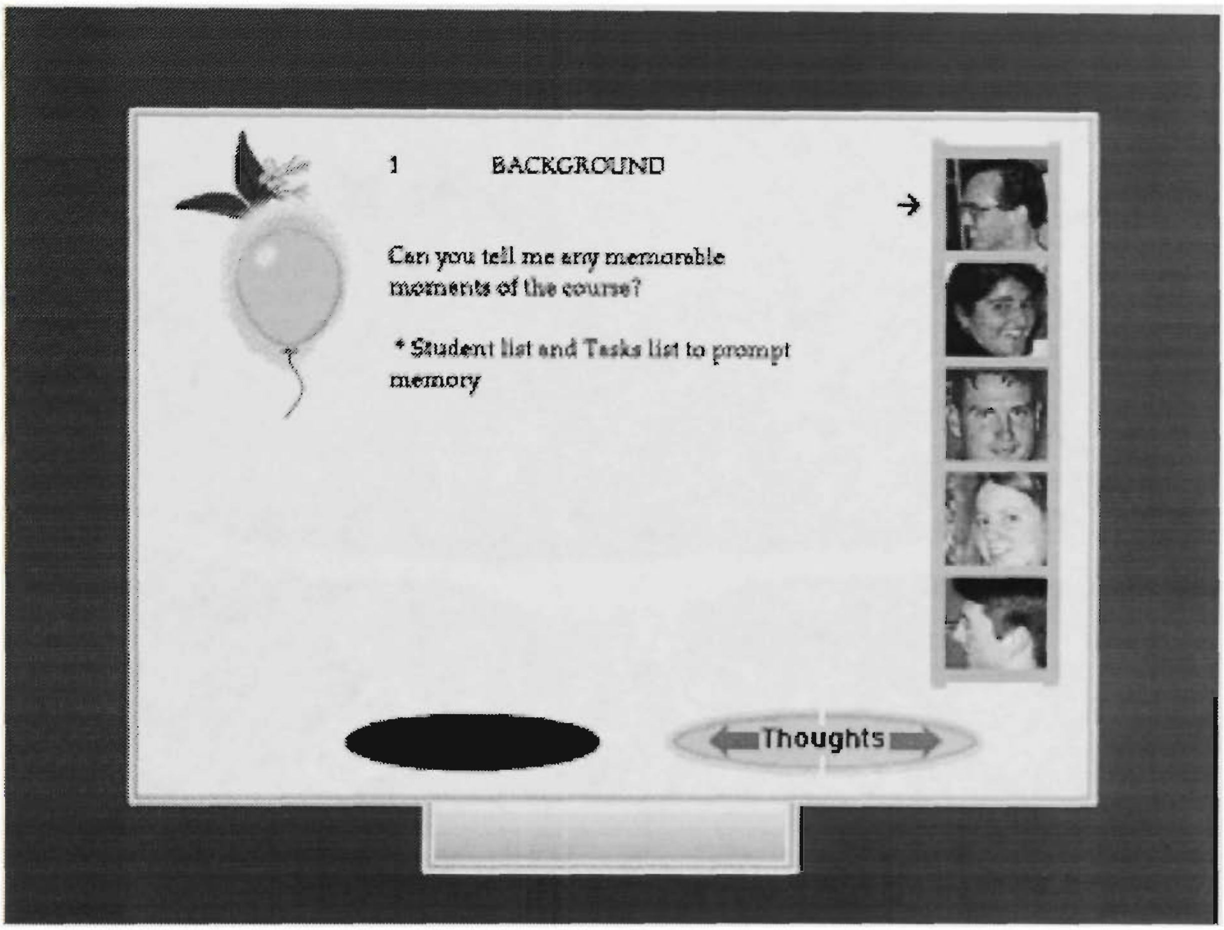
While the "Teacher Notes" permitted the researcher to regain a sense of the class each week, they did not help step into the shoes of individual students. By extracting notes for these five students througout the full study period, the researcher was able to gain a sense of the differences between the pathways taken by each student, despite the "common" environment.

### Navigation Options :

You may select a class by clicking on one of the timeline segments along the lower screen, or progress through the classes in sequence using the arrows. Data may be read at different levels of student specificity be selecting a radio button option. The EDUM Tree flower in the lower right corner will return you to the EDUM Tree to browse further case details.

## Map : EDUM Balloon 3

Selection of the balloon beneath the right side of the EDUM Tree permits you to listen to student answers to the questions which are listed in Appendix J. There were only five students in this group, and the interview process was in depth. Sound files permit you to hear the emotion, enthusiasm and humour which can be lost in a transcript.




### Design Rationale :

Images of students are small, and preserve more privacy than names. The researcher felt that sound files alone did not convey the same depth of information as the combination of image and sound file.

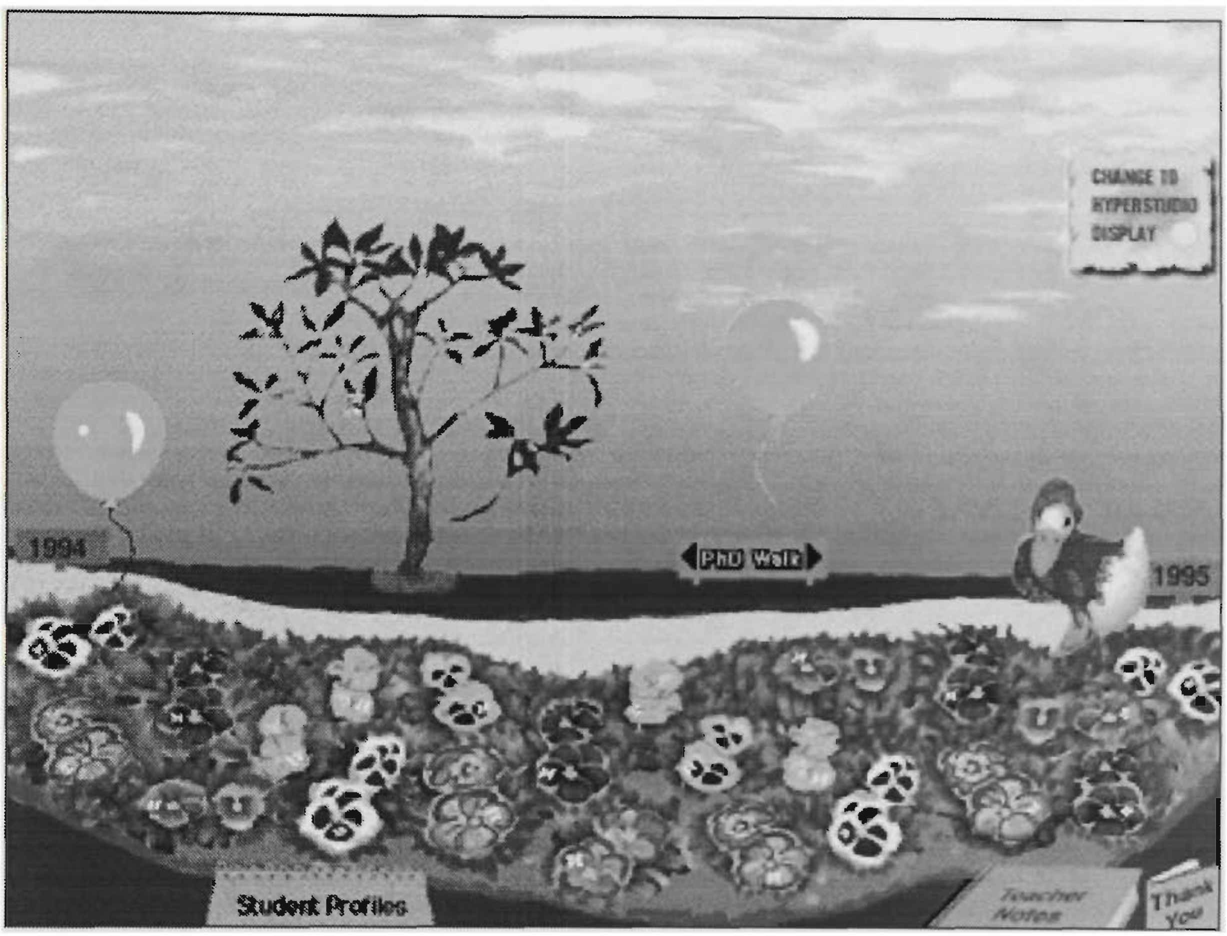
[ NOTE : All other balloons contain either a text record of student comments, or sound files, where these were appropriate. Balloons for the G&T case are presented in a similar manner.]

### Navigation Options :

You may hear the multiple perspectives on any question by selecting each student image, or hear the full perspective of one student by stepping through all questions and selecting the same image. Selection of 'EDUM Tree' returns you to the EDUM Tree to view more case related material.

## Map : The G&T Bed

Selection of the G&T Bed in the "PhD Walk", then the palette option to "Let Me See". permits you to access a range of student project work, the thank you card, student and teacher thoughts, researcher notes on all classes, and student profiles.




### Design Rationale :

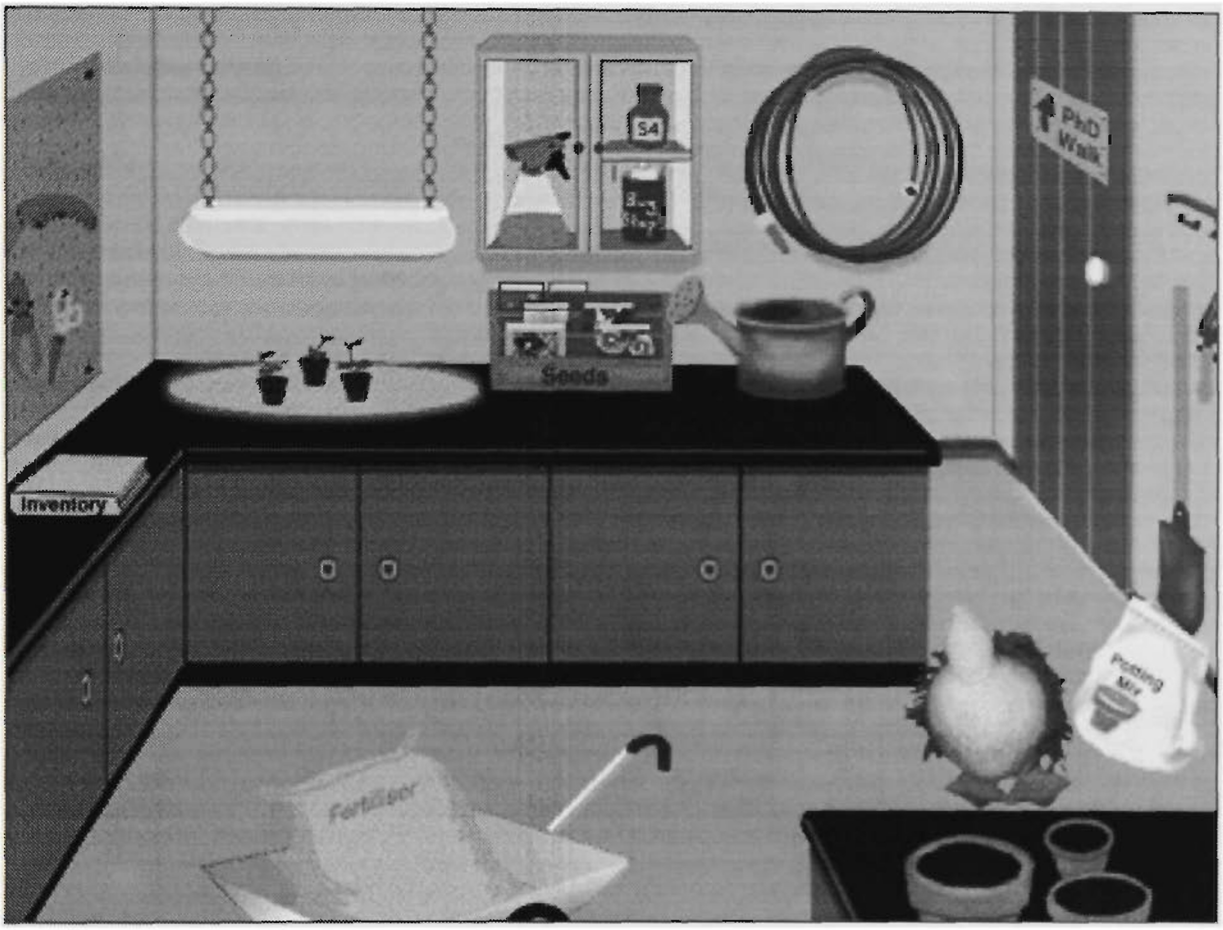
Student profiles and teacher notes can be accessed from the books in the foreground. Balloons hold student comments and an interview with the class teacher. Each pair of pansies represents the work of a student. Similar flower colours indicate students within the same project group. All flowers with white moths access the group HyperStudio® project. The alternate flowers of each pair access earlier student work in HyperStudio®.

### Navigation Options :

Selection of any flower will open the attached project work. Since all project work was in HyperStudio®, choose "Change to HyperStudio Display" to see these projects. Teacher notes and student profiles are in HyperCard®. The signpost will return you to the "PhD Walk". Selection of the EDUM Tree will take you straight to the other case study.

## Map : The Toolshed

Selection of the Toolshed in the "PhD Walk", then the palette option to "Let Me See", permits you to access a range of software tools constructed by the researcher. These have been categorised according to the metaphor of teacher as gardener. More details of this comparison can be found within the yellow inventory book on the toolshed bench.




### Design Rationale :

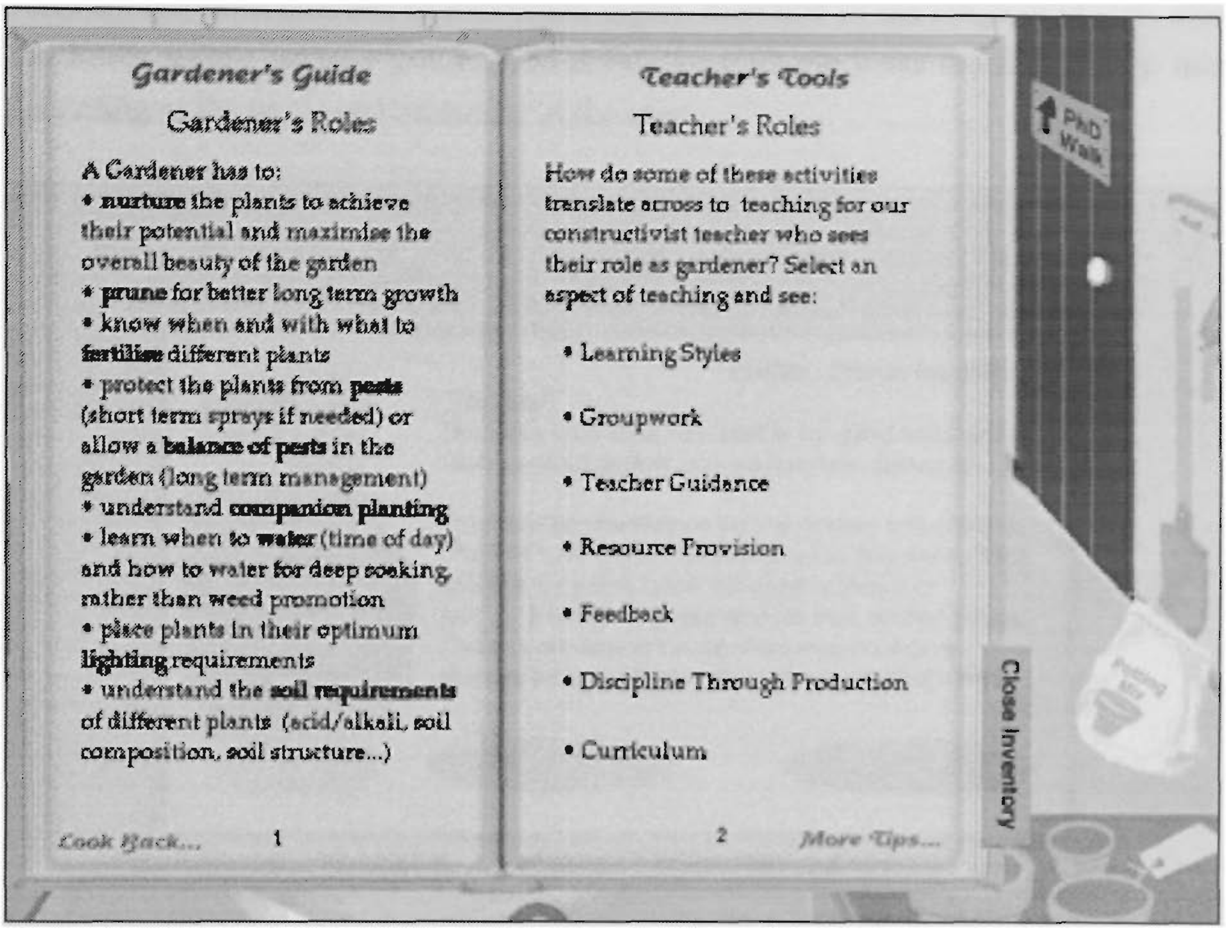
This toolshed looks more like an orderly kitchen than the researcher's real toolshed. However, it houses functional tools in an orderly manner, rather than the discarded prototypes which belong on a metaphoric compost heap, their code snippets ripe for re-cycling. The objects within this graphic indicate the key acitivities of the gardener, such as watering, fertilising, potting and pruning. Software tools which provide comparable functionality for a teacher are attached to these objects.

### Navigation Options :

Selection of any toolshed object with the exception of the inventory will open the linked software, via an overview screen (see the following map). The doorway leads you back to the "PhD Walk".

## Map : Toolshed Inventory

Selection of the inventory book within the Toolshed reveals a comparison between the roles of the gardener, and the roles of a teacher.




### Design Rationale :

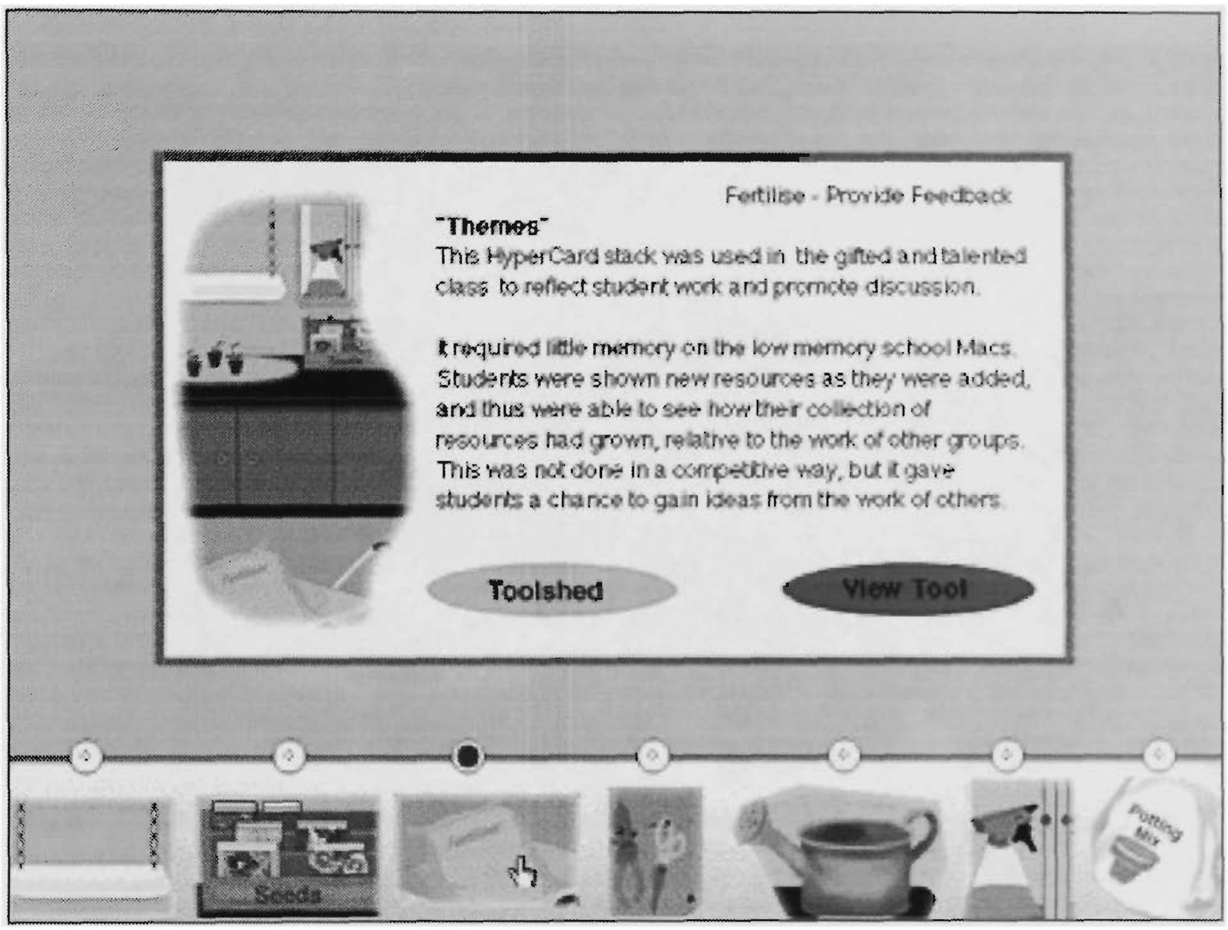
This metaphor of teacher as gardener provides the basis for accessing all the software tools in the toolshed. The extent to which the researcher has explored this metaphor needs some explanation, which is provided in this inventory. Initially the researcher envisaged a chronological presentation of tools on a shelving system, however, this was nowhere near as informative or flexible as the functional themes accompanying the multiple roles of teacher as gardener.

### Navigation Options :

Selection to read 'More Tips...' or 'Look Back...' is your navigation system to read the book. Software examples are discussed in the inventory, but must be accessed from the gardening objects within the toolshed. Select the book tab 'Close Inventory' to return to the toolshed. The doorway leads you directly back to the "PhD Walk".

## Map : Tool Selection

Selection of an object in the Toolshed leads you to this detailed dialog screen, which permits you to browse the many possible uses of the selected tool. While each piece of software has been attached to a toolshed object, selection of the range of objects along the lower screen permits you to read about the multiple ways the tool can be used, according to the needs and creativity of the user.




### Design Rationale :

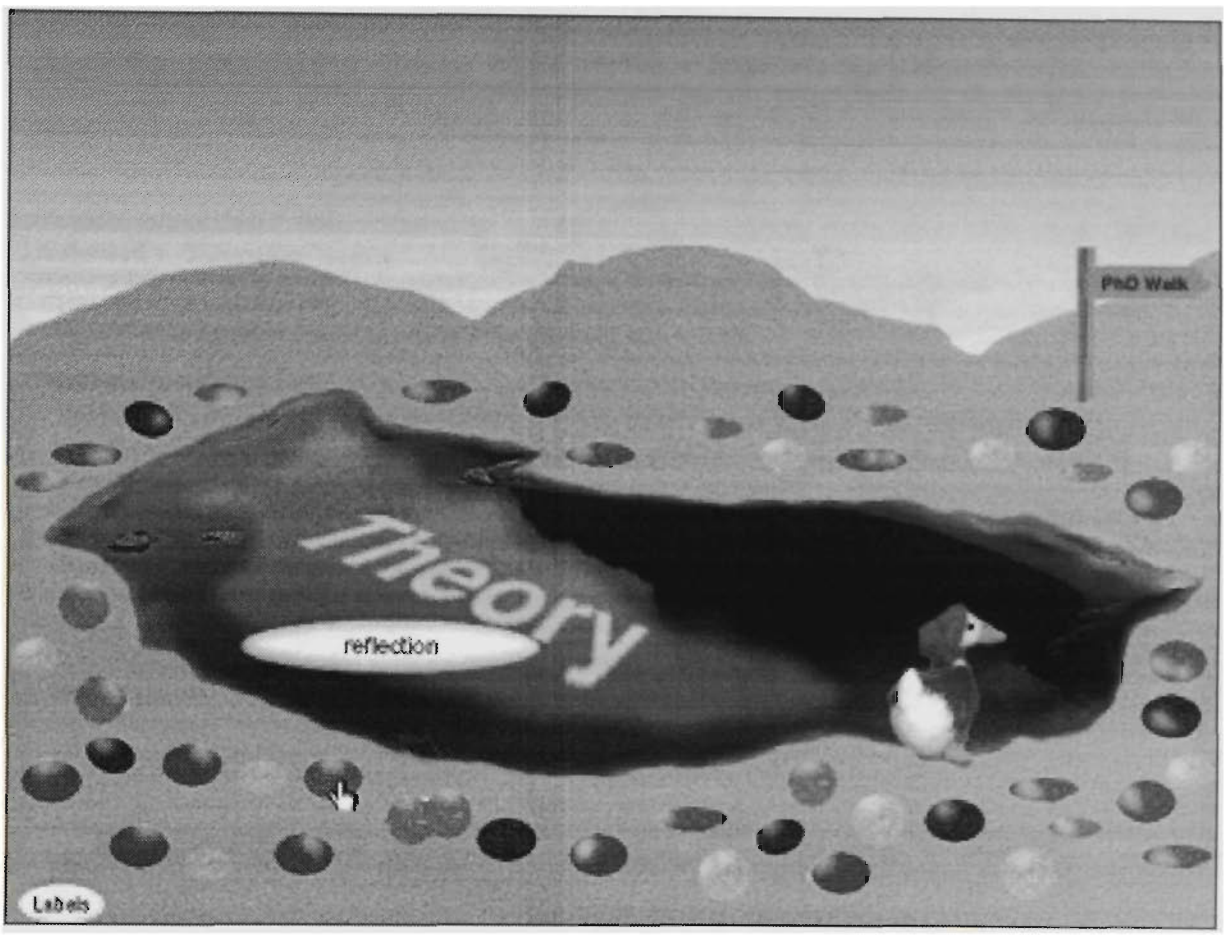
The use of any software tool is determined by the creativity and needs of the user. Each piece of software in the toolshed could be used in many ways— to provide feedback, support student construction, provide resources, foster collaboration, frame a task or tailor for certain learning styles.

### Navigation Options :

Selection of any theme along the lower screen will allow you to read about different uses of the software tool. You can then select 'Toolshed' to return to the toolshed or 'View Tool' to view one use of the tool— the original one described when you selected the tool.

## Map : The Theory Pool

Selection of the Theory Pool in the "PhD Walk", then the palette option to "Let Me See", permits you to access this space within *The Garden*. Selection of the theory option in the palette of any key object in the "PhD Walk" will bring you to the theory pool with only the relevant theme accessible. Each pebble around the pool represents a key concept or author, the identity of which is revealed in the white oval in the theory pool as you run the cursor over the pebble.




### Design Rationale :

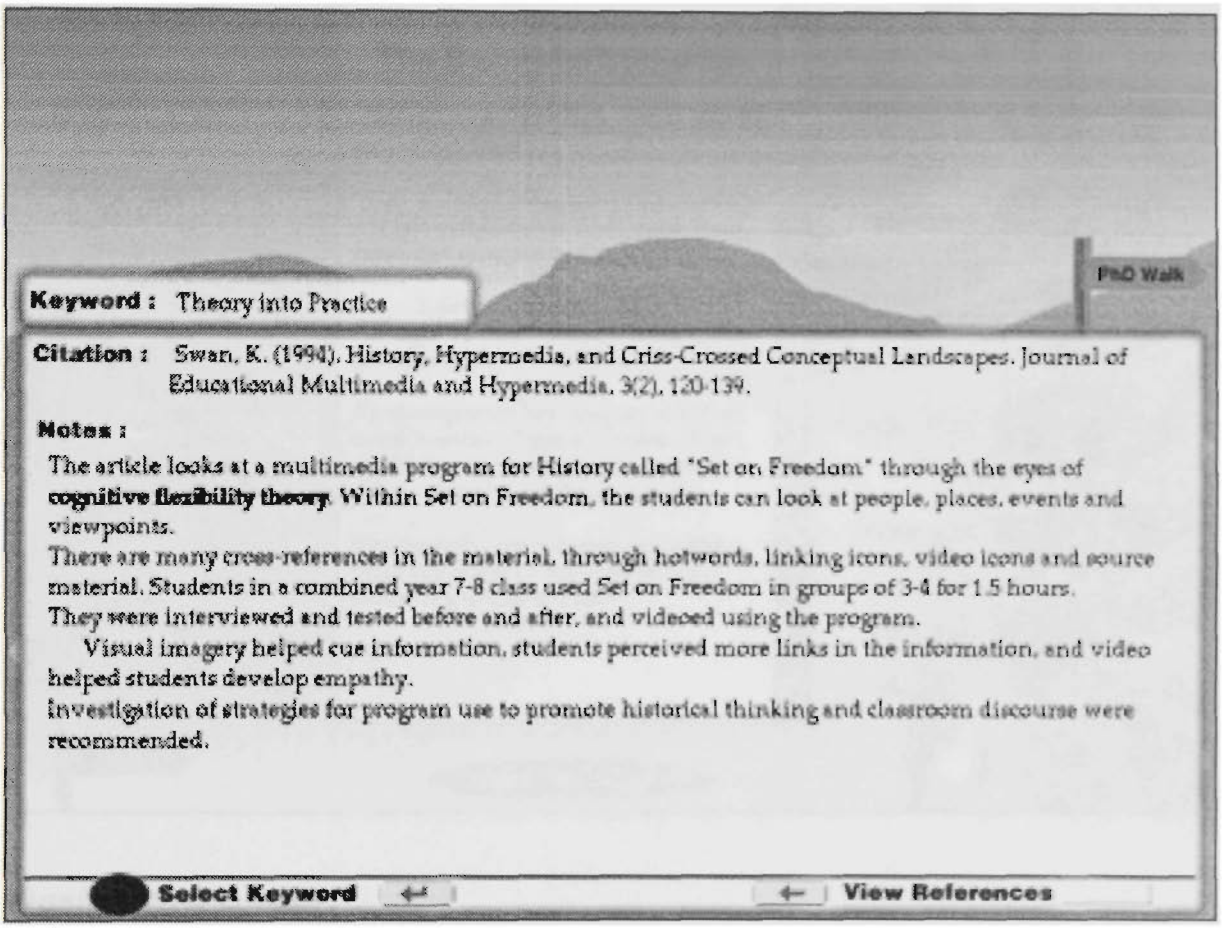
The theory themes are colour coded to allow you to pursue a researcher-designated theme. The pink theme relates to classroom issues, the blue to theory, the yellow to instructional design, the purple to software tools, and the green to deeper philosophical issues and key authors.

### Navigation Options :

Selection of any pebble opens an annotated bibliography dealing with that concept or author. Once within a colour theme, you may step through all entries within it, or return to the theory pool to change themes. The signpost will return you to the "PhD Walk".

## Map : Annotated Bibliography

Selection of any pebble opens an annotated bibliography dealing with that concept or author. The concepts and authors which have made their way into this annotated bibliography are the ones which have impressed the researcher at the end of the study. EndNote® was used to store citations of all literature read, but this theory pool is the repository for special material of future use to the researcher.




### Design Rationale :

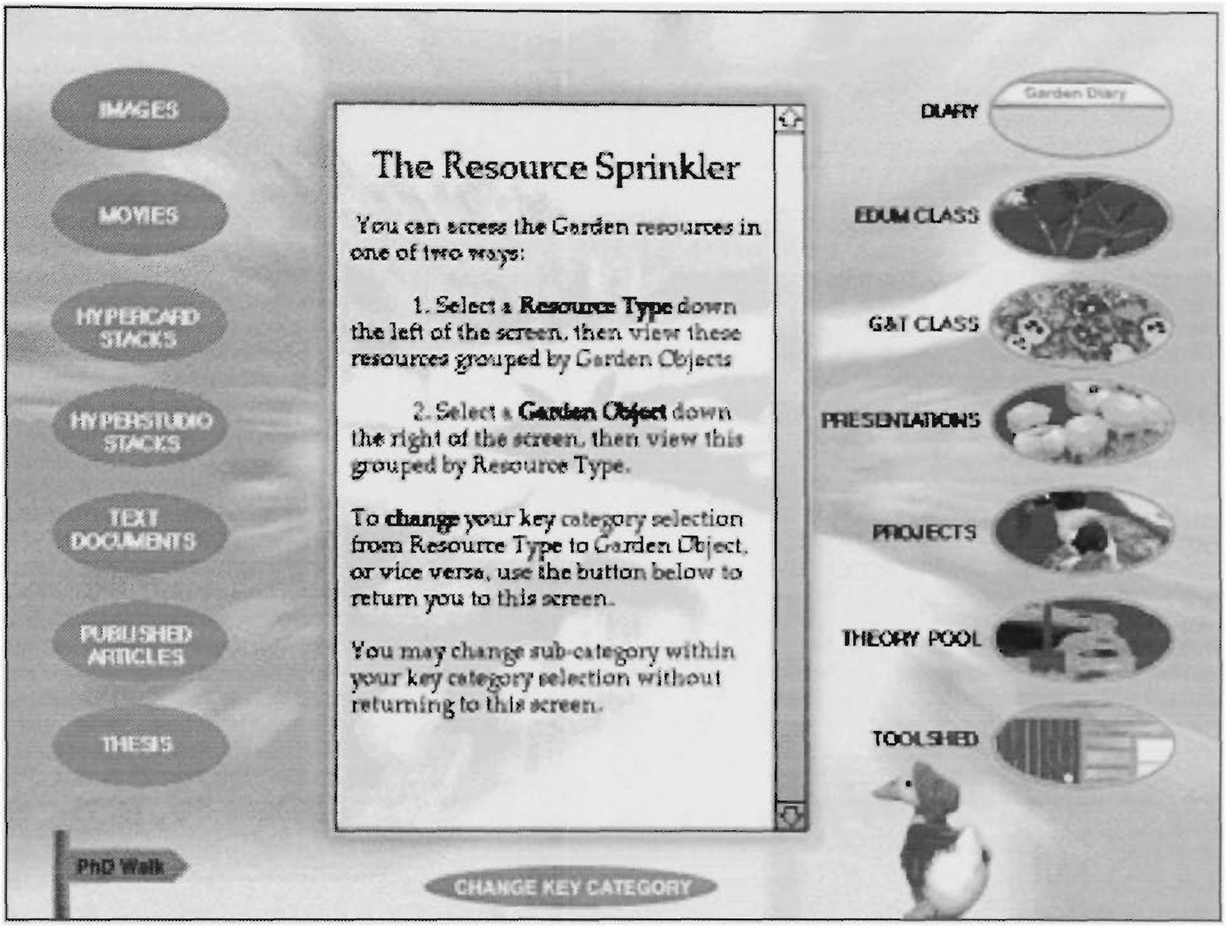
Initially the text presentation area for each concept was oval-shaped to match the pebble selection. This was not practical or effective— text within rectangular fields overhung the pebble edges, or was difficult to read down a jagged left edge. The researcher wanted the capacity to include a reasonable amount of text for personal use, particularly the recording of quotes. Practicality and functionality therefore drove simple rectangular design.

### Navigation Options :

You may either browse backward or forward through the references within a concept or theme, or return to the theory pool to select another keyword. Direct return to the "PhD Walk" is via the signpost.

## *Map : The Resource Sprinkler*

Selection of the Sprinkler in the "PhD Walk", then the palette option to "Let Me See", permits you to access all the material on the CD *THE GARDEN* by resource type or by theme.




### *Design Rationale :*

There may be times when it is important to compare all images across themes (garden objects), or rapidly access a particular resource within a theme. The sprinkler allows you to control what you view very precisely, devoid of the graphic context of the visual space. For example, a HyperStudio® stack can be called up by title within the G&T class. This same stack would be "discovered" randomly within the G&T bed, anchored to a particular flower colour.

### *Navigation Options :*

Initial selection of a resource type allows you to compare that resource across themes by selecting different themes. If you choose to select a theme (garden object) first, you can choose different resource types within that theme. To change your primary selection criteria, select 'CHANGE KEY CATEGORY'. The signpost will return you to the "PhD Walk".