The Development of Intelligent Hypermedia Courseware, for Design and Technology in the English National Curriculum at Key Stage 3, by the Sequential Combination of Cognition Clusters, Supported by System Intelligence, Derived from a Dynamic User Model

A thesis submitted to Middlesex University in partial fulfilment of the requirements for

the degree of Doctor of Philosophy

Andrew Bardill

School of Lifelong Learning and Education

Middlesex University

February 2003

THIS THESIS CONTAINS A CD WHICH
WE ARE NOT PERMITTED TO COPY

PLEASE CONTACT THE UNIVERSITY
IF YOU WISH TO SEE THIS MATERIAL

Abstract

The purpose of this research was to develop an alternative to traditional textbooks for the teaching of Electronics, within Design and Technology at Key Stage 3, in the English National Curriculum. The proposed alternative of intelligent hypermedia courseware was investigated in terms of its potential to support pupil procedural autonomy in task directed, goal oriented, design projects. Three principal design criteria were applied to the development of this courseware: the situation in which it is to be used; the task that it is to support; and the pedagogy that it will reflect and support. The discussion and satisfaction of these design criteria led towards a new paradigm for the development of intelligent hypermedia courseware, i.e. The sequential combination of cognition clusters, supported by system intelligence, derived from a dynamic user model.

A courseware prototype was instantiated using this development paradigm and subsequently evaluated in three schools. An illuminative evaluation method was developed to investigate the consequences of using this courseware prototype. This evaluation method was based on longitudinal case studies where cycles of observation, further inquiry and explanation are undertaken. As a consequence of following this longitudinal method, where participants chose to adopt the courseware after the first trial, the relatability of outcomes increased as subsequent cycles were completed. Qualitative data was obtained from semi-structured interviews with participating teachers. This data was triangulated against quantitative data obtained from the completed dynamic user models generated by pupils using the courseware prototype. These data were used to generate hypotheses, in the form of critical processes, by the identification of significant features, concomitant features and recurring concomitants from the courseware trials. Four relatable critical processes are described that operate when this courseware prototype is used. These critical processes relate to: the number of computers available; the physical environment where the work takes place; the pedagogical features of a task type match, a design brief frame match and a preferred teaching approach match; and the levels of heuristic interaction with the courseware prototype.

Contents

Chapter 3: **Operationalising the Research**

Chapter 4:   The Case Studies

Table of Figures

Chapter 3

Section 1

Section 2

Section 4

Section 5

Chapter 4

Section 1

Section 2

Section 3

Chapter 5

Chapter 6

Chapter 1 - Research Overview

Background to this Research

The principal motivation to undertake this research project stemmed from this

researcher's experience as an author of secondary school level Design and Technology

text-books. These books covered a variety of subject matter, but had a definite focus on

'systems and control', which is the area of Design and Technology that currently

encompases electronics. The text-books that support Design and Technology have

become the de-facto knowledge base of the subject and, as such, have a dual audience.

Pupils use them as sources of information, motivation and guidance when undertaking

their Design and Technology project work. Teachers use them as a source of material to

support their teaching, but may also consult them for project ideas and as a readily

accessible method of updating or expanding their own subject knowledge. It is not

contentious to say that the subject of Design and Technology is concerned with

designing and making. It is perhaps inevitable that the text-books used to support a

subject with designing at its core tend to fall into one of two broad categories, i.e.

sources of context free information and look-up data and sources of context based

project ideas with background information. It is a relatively straightforward task to write

a useful textbook that supplies context free information and look-up data as the author

need give no consideration as to how the information is used by the reader. They simply

need to ensure that the information given is relevant to the level of its users and to the

curriculum that they are interacting with. However, the task becomes more complex

when attempting to write a useful textbook that can supply context based project ideas and support these ideas with the necessary information for readers to complete their own individualised project. The complexity lies in supplying enough information to enable a meaningful range of possible outcomes from the project, yet enable individual users to gain sufficient support for their own individual project and not get confused or diverted by the information that is extraneous to their project once it has begun. Extraneous that is until their project demands or ideas change and they need to access it again, or they need to make selections from closely related options. A difficult balancing act that is frustrating for authors to attempt and all but imposible for them to sucessfully evaluate in the normal writing context. This phenomenon is particularly pronounced when dealing with electronics. The system components chosen represent some of the most significant design decisions taken by pupils doing the project. These system components are always connected to their related stages. Any given option must have the potential to function with any other option in the system format given by the project.

So the book, or learning resource, needs to supply sufficient information to support a project, where the information is sensitive to the design context of its user, and is useful and productive for a range of individual users who find themselves in these design led situations. If asked to step back from the current situation and to design a new solution to this evident need then a book, in a traditional codex form, is unlikely to be put forward as the ideal solution. What one might ask for is some form of 'agent' that can 'decode' the text for its individual users; essentially an intelligent book that can adapt itself to its users.

The 'agents' in the current scenario are teachers who control the interaction between the texts and their pupils, effectively becoming the conduit through which pupils access the knowledge base of the subject. However, there are implicit difficulties with this approach that might be improved upon by alternative approaches. These difficulties are

different for different teachers, but might be broadly classified into two themes. These themes are typified by the levels of teacher expertise in the subject of electronics, when it is used as the technological vehicle for design activities. Teachers who have a well developed level of expertise in this subject area may well be confident and capable in using, modifying and developing learning resources for their pupils. However, such activity is costly in terms of teacher time and,because of the necessity for the teacher to take the central role in managing their pupils' accesss to the knowledge base, it may restrict the levels of personal, procedural autonomy that pupils may attain and exhibit during their Design and Technology work. Essentially, there will be physical limits applied to the levels of control over the project that teachers can give to their pupils by these practical information provision concerns, brought about by the limitations of the human 'conduit' working with a number of pupils. Design and Technology teachers who do not have a specialist expertise with electronics will have a heavy dependence on the available learning resources. The problems associated with producing satisfactory resources have been highlighted above and, hence, these teachers may simply become the conduit that passess on the resource deficiencies to their pupils. Again these deficiencies are likely to result in an innapropriate restriction to the levels of personal procedural autonomy that their pupils can develop and exhibit [1].

Evidently a book that can adapt to its users would overcome the difficulties highlighted above by freeing teachers from acting as either form of 'conduit'. Pupils could be provided with information that is relevant to their own personalised interpretation of the project. Teachers could be provided with a learning resource that enables them to pass sufficient levels of control over the project to their pupils, to enable them to develop and exhibit their levels of personal, procedural autonomy whilst undertaking the project.

[1] The notion and importance of personal proceduaral autonomy in Design and Technology activity is taken as understood in this introduction, but is investigated and discussed in Chapter 2 of this thesis.

Unfortunately such books, or learning resources, do not exist. They are unlikely to do so

unless alternative platforms and delivery mechanisms are considered and devised.

Clearly information technology has a significant role to play in developing such forms

of learning resource. This potential role becomes highlighted when the emergent

technological manifestations of the theoretical constructs of hypertext and hypermedia

are considered, e.g. Computer based knowledge domains, CD-ROMs, and the World

Wide Web [2]. Such systems enable the non-sequential presentation of information,

which might enable personalised learning resources to be constructed. Furthermore,

these systems become even more seductive when the potential offered by the

developing capabilities of expert systems and artificial intelligence enter in to the

knowledge base construction 'equation'.

Initial Research Aims

This research project aimed to investigate the potential of hypermedia to be used as an

alterntive to text-books to support the teaching of electronics as part of Design and

Technology. It aimed to develop a prototype learning resource with the capability to

deliver context sensitive, individualised information for users in design led situations,

that could support developing levels of procedural autonomy in pupils. Furthermore, as

a natural part of this design and development project, it aimed to investigate and

understand how this prototpye resource interacts with the learning situation into which

it is introduced in order to evaluate its efficacies and deficiencies. As such, this current

research project aimed to solve a real world problem. Phillips and Pugh provide much

support and guidance to Ph.D. researchers, but also warn that when undertaking

problem solving research, researchers will need to,

---

[2] These theoretical constructs and their technological manifestations are taken as understood in this introduction.
They are described, investigated and discussed in Chapter 2 of this thesis.

> *...Bring together all the intellectual resources that can be brought to bear on its solution. The problem has to be defined and the method of the solution has to be discovered. The person working in this way may have to create and identify original problem solutions every step of the way. This will usually involve a variety of theories and methods, often ranging across more than one discipline. Since real-world problems are likely to be 'messy' and not soluble within the confines of an academic discipline.*

(Phillips. E. and Pugh. D. 1994 p.50)

With this warning in mind it is evident that these initial research aims were, by necessity, less well defined than those described above at the outset of the project and became more tightly defined as the project progressed. A tight definition of all aspects of the project from the outset would negate any design process. Initially the project could aim to do no more than develop a prototype hypermedia based learning resource as an alternative to a text-book, where the 'alternativeness' was largely undefined. Furthermore, it was not possible to understand how to evaluate the prototype until the nature of the prototype was understood. However, as the process of problem definition progressed, via consultation with the literature, it was possible to understand and define the nature of this alternative approach. This understanding and definition led to an evident opportunity to develop a new paradigm for courseware deveopment, i.e. the sequential combination of cognition clusters, supported by system intelligence derived from a dynamic user model [3]. Moreover, with the development of this new paradigm came the opportunity to investigate how courseware instantiated within this paradigm might be usefully evaluated.

---

[3] The term 'courseware' is used to denote the hypermedia based learning resource. The new paradigm is noted in the Sysnopsis in this chapter and is fully described in Chapter 2.

Research Questions

With the research and development nature of this project in mind, and its aim to solve a loosely defined, real world problem, it is evident that the reseearch questions changed and developed as the research progressed. These questions were initially targetted at the problem definition phase of the project:

1. What are the needs associated with developing subject capability in Design and Technology?

2. How do these needs relate specifically to the technology of electronics when it is used as a vehicle for design activities?

3. What are the opportunities to address these needs using a hypermedia based learning resource?

4. What are the design criteria to be applied to such a resource?

These four initial research questions were addressed in Section 1 of Chapter 2 in this thesis. Answering these questions made it possible to frame the next major question in the solution development phase of the project:

5. How can intelligent hypermedia courseware be developed that can resolve the conflicting and supporting elements of its design criteria, in learning situations that are structured by task-driven, goal oriented concerns?

This fifth question was addressed in Section 2 of Chapter 2 in this thesis and the answer resulted in a new paradigm for courseware development. This courseware development paradigm enabled the instantiation of a courseware prototype. Answering the problem definition and solution development research questions made it possible to frame the research questions relating to the evaluation of the resource:

6. In using this intelligent hypermedia, as an alternative to text-books to support project based learning, what will the factors be that affect its efficacy in addressing the issues of developing capability, increasing levels of pupil procedural autonomy and the support of teachers in the release of control to pupils?

7. How will these factors affect teachers' opinions of the courseware?

8. How might these factors be used to inform subsequent courseware development in an era when there are increasing motivations to use it?

9. What are the areas for further consideration and research?

Initial Methodological Considerations

Although developmental in nature and based in a real-world, problem-solving context, this current research project clearly broke down into two separate but interrelated phases:

Phase 1 - Developing the courseware (research questions 1 to 5)

Phase 2 - Evaluating the courseware (research questions 6 to 9)

The majority of phase 1 was completed whilst undertaking the literature review (Chapter 2), leaving the instantiation of the prototype to take place before phase 2 was begun. The multi-disciplinary nature of this project required literature to be reviewed from a variety of disciplines, but focussed principally upon Design and Technology education and hypermedia in an educational context [4]. The use of literature from

---

[4] The phrase 'hypermedia in an educational context' is used to avoid the extant terminology of the educational use of computers, e.g. Computer Aided Learning (CAL), Computer Assisted Instruction (CAI), Computer Based Trainning (CBT), Computer Aided Education (CAE), etc. to remain free from the individual ideologies and methodologies encompassed by them.

Design and Technology education needs little explanation because of its central focus in this curent research project. However, the limitation of the second principal area to hypermedia used in an educational context, rather than the much broader area of hypermedia per se, needs some justification. This limitation was applied as a reasonable and rational focussing exercise applied to an area of literature that would be unproductively large and diverse had it not been applied.

As the literature review progressed, and the intelligent hypermedia development paradigm emerged, it became possible to instantiate a prototype. The instantiation process following a research and development model guided by the principles of individual author prototyping [5]

Having instantiated a prototype intelligent hypermedia learning resource, that exemplified the principles of the answers to research questions 1 to 5, it was then possible to engage in evaluation trials to address research questions 6 to 9. In answering these questions, which are illuminative in nature, it was necessary to construct and deploy an illuminative evaluation methodology. This methodology was principally based upon longditudinal case study methods with data collected from two main sources. The first source being semi-structured interviews with the participating teachers resulting in qualitative data. The transcripts of these interviews were used to gain insight into the significant features operating during a trial. The second source of data was collected by the courseware as a consequence of the users interactions with it in the form of quantitative data. This data essentially forms a collection of virtual trace measures, which collectively constitute a 'user model'. This user model is a vital component in the maintainence of the courseware intelligence, i.e. its ability to adapt to its user. These user models were used to identify further significant features of the trial and to triangulate the data from the interview transcripts. The analytical method then

[5] The principles of individual author prototyping are discussed fully in Section 1 of Chapter 3 of this Thesis.

sought to identify and describe the concomitant features of a trial by describing the possible concomitant relationships between the significant features identified. This range of concomitant features were then used to identify any recurring concomitant relationships that operated across the trials and, hence, to describe the emergent critical processes that operated when this learning resource was used. These critical processes are the relatable outcomes from this current research project. Illuminative methods, as exemplified in case study approaches, are hypothesis generating rather than hypothesis testing research methods. (Robson. C. 1993 p.19) This process of generalizing to theory, or critical process, via the significance, concomitance and recurring concomitance of the features of the trials exemplifies this hypothesis generating approach.

Contribution

This current research project makes claim to the following substantive contributions to knowledge:

• In attempting to solve the real-world problem of developing courseware that can support teachers and pupils in task-driven, goal-oriented learning situations, where pupils undertake task types that demand relatively high levels of procedural autonomy when compared to other task types, a new courseware development paradigm has been designed, viz:

The sequential combination of cognition clusters, supported by system intelligence, derived from a dynamic dynamic user model.

• In trialing a courseware prototype, that has been instantiated under the guidance of this new courseware development paradigm, an understanding of the critical processes that affect its efficacy in a small range of learning situations has been gained. The range of trial scenarios was too small for the outcomes to be generalised to any significant

extent. However, the critical processes that emerged from the trials can be related to other learning situations with similar features. [6]

Synopsis

Chapter 1 - Project Overview

This chapter provides an introduction to this current research project. The initial research aims are discussed and how the nature of this project, set in a real-world [7] problem solving context, demanded an evolutionary set of research questions. The nine research questions are identified and indications of the chapters in which they are discussed and answered are given. This chapter continues with an overview of the methodological considerations for this current research project and finsihes with a quick overview of the project outcomes and recommendations for further work.

Chapter 2 - Defining the Problem and Proposing the Solution

This chapter constitutes the literature review and focusses on research questions 1 to 5. Questions 1 to 4 are answered in section 1 and a possible answer to question 5 is put forward in section 2.

Chapter 2, Section 1 - From Here to Uncertainty

This section discusses the design requirements of the courseware resource. Three principal design criteria are applied; those of the situationthat the courseware is to be used in, the task that it will be used to complete and the pedagogy tha it will reflect and support. Issues of Design and Technology capability are discussed and models for the engendering of capability in a progressive way are presented and developed. The role of hypermedia in

---

[6] These four critical processes resulting from the trialling and evaluation of the courseware are fully described in Chapter 6 of this thesis.

[7] In the context of this research, 'real-world' is taken to mean fully naturalistic settings that do not have controls applied for the purposes of the research.

education is discussed and the problems associated with its use are highlighted.
Arguments for the use of 'intelligent hypermedia' within the particular context
of Design and Technology at Key Stage 3 are put forward and the
appropriateness of courseware that utilises this emergent paradigm is
investigated. A continuum of approaches to courseware design is developed
that ranges between behaviouristic and constructivist pedagogies. An evident
need to traverse this continuum in the completion of tasks is identified.

**Chapter 2, Section 2 - Resolving the Uncertainty: A New Courseware
Development Paradigm**

Developing the discussion from the previous section, this section describes the
design of the structure and the operation of the courseware. The three principal
design criteria (situation, task, pedagogy) are used as the basis for the
formulation of a design specification, the satisfaction of which reiterates the
need for a traversal of the continuum of courseware design approaches in the
completion of a task. The role of a user model in controlling this traversal is
investigated and its possible application by the system is used to develop a
model for courseware interaction. This model is subsequently developed into
the notion of a 'cognition cluster' and, by their use, a new paradigm for the
construction of courseware is proposed, i.e. the sequential combination of
cognition clusters, supported by system intelligence derived from a dynamic
user model. The courseware is then designed within this paradigm by definition
of the requisite cognition clusters.

Chapter 3 - Operationalising the Research

This chapter focuses on operationalising the research. Its five sections are concerned
with developing the project methodology, implementing the resultant methods,

instantiating the courseware prototype, developing the research instruments and describing the analytical method. This chapter prepares the ground to answer research questions 6 to 9.

Chapter 3, Section 1 - Project Methodology

This section develops the project methodology with reference to its two major phases:

• Phase 1 - The design and production of the courseware

• Phase 2 - The trialing and evaluation of the courseware

A courseware prototpye development methodology, which overlays and unifies these two distinct phases, is developed. This methodology is initially based on research and development methods for phase 1 and illuminative methods for phase 2. The differing aims of these methodologies are brought together in this current real-world, problem solving research project to form a coherent and progressive courseware design, development and evaluation process. This coherence is enabled firstly by recognising and incorporating the interplay between the evaluative concerns of the developer and of the users. This interplay, and the relative importance of the two contributors as the phases progress, is described and incorporated into the methodology model. Further coherence is enabled, in this progressive model, by recognising and incorporating the need to make a gradual transition in the nature of the courseware evaluation environments, i.e. from controlled, through quazi-naturalistic, to fully naturalistic settings. The resultant methodology model represents a process whereby the evaluation of the developing courseware can be passed from developer to user via a sequence of conceptualisation, testing, trailing and adopting the courseware. The final phases of this evaluation

methodology represents an illuminative cycle of observation, further inquiry
and explanation, whereby the explanation increases the relatability of outcomes
as each cycle is completed.

Chapter 3, Section 2 - Project Implementation and Time-scale

This section details the time period and intervals over which the project was
implemented. It details how the 'opportunity basis' courseware evaluators were
co-opted and explains a 'talk as you go' evaluation method that was used
during the courseware development phase of this project. It details when the
trials took place during phase 2 of this project and discusses why the start-point
was chosen. This start-point is justified with respect to the developed project
methodology and the need for users to adopt the courseware if relatable
outcomes are to result from this trialing phase.

Chapter 3, Section 3 - Instantiating the Courseware

This section is a reflective journal that describes the instantiation of the
courseware prototype. It explains how the prototype developed as a result of
the influence of the development paradigm and as a response to user feedback.
The naturalness of the testing environment is increased as the courseware
prototype develops, in accordance with the developed project methodology
model. This change in the testing environment enables a shift in courseware
development issues from a micro to a macro level and this shift is reflected in
the subsequent developments in the courseware prototype.

Chapter 3, Section 4 -Developing the Research Instruments

This section discusses the development of the two principal research
instruments, i.e. the interview schedules and the courseware user model data
extraction tools. It describes the outline process of how the qualitative data

elicited from the interview transcripts is triangulated against the quantitative data from the courseware user models to identify the significant feartures from a trial and the concomitant relationships between these features. It goes on to indicate how this range of concomitant features can be used to identify the recurring concomitants and how these recurrent relationships can be used to describe the emergent critical processes that operate when this courseware is used. A model of this outline process is presented in diagramatic form.

Chapter 3, Section 5 - Analytical Method

Continuing the discussion in section 4 of this chapeter, this section provides the fine detail of how the data, collected via the two principal research instruments, was analysed. It describes the analytical processes used to identify the significant features and concomitant features from a trial. The analytical processes described include:

• the tagging of interview transcripts against nine criteria. Three of these criteria related to the participating teachers' previous experience of electronics and computers in Design and Technology and the remaining six were translated from the courseware design specification;

• the sorting of the courseware user model data into nine indicative sets and the presentation of these data sets in diagrammic, or tabular form, to enable triangulation with the interview transcripts. The nine data sets were: the level of deviant courseware interaction; the courseware engagement and completion fall-off; the overall visit concurrency profile; the profile of visit concurrency by cognition cluster; the visit concurrency by log-in order; the courseware completion by log-in order; the profile of systems built by pupils; the number and type of systems modifications made by pupils; the profile of activities during the 'design visit' to the courseware.

This section concludes with a twelve point process describing how the analytical method was undertaken.

Chapter 4 - The Case Studies

This chapter presents the case studies from this research project. These case studies present the contextual detail, and trial data, that are used in subsequent chapters to answer research questions 6 to 9. Each case study begins with a 'pen picture' of the trial school to place the study into context. This 'pen picture' includes information about the school as a whole, the Design and Technology department, the staff, the resources and the rooms used for the trials. The interview tagging process enables a trial interview commentary to be constructed and this commentary is used to identify the major issues to emerge from the trial. The nine data sets extracted from the courseware user models are presented and commented upon. The analysis of this data enables a courseware data commentary to be constructed around the major issues to emerge from this data. This commentary is informed by the major issues identified as a result of the interview commentary. These two commentaries enable the identification of the significant features from the trial and the description of their concomitant relationships. The process, thus described and presented, is repeated for the adoptive trial in each case study presentation.

Chapter 5 - Recurring Concomitants and Critical Processes

This chapter brings together the major outcomes from the case studies (the concomitant trial features) in order to identify the recurring concomitants, the possible relationships between recurring concomitants and, thence, to identify and describe the emergent critical processes. This identification and description process is guided the three principal design criteria used in the development of the courseware (situation, task, pedagogy). The task and pedagogy criteria are joined as their interrelationship becomes inextricable at the final stage of the courseware development process.

Two critical processes were identified that relate to the situation features of the courseware trials:

• Critical Process 1 describes the relationship between the physical environment and the level of deviant courseware interaction. Four types of deviant interaction are identified and described - poggling, redemption, subversion and the 'solitary-disadvantaged'. The critical process describes the relationships between these four deviant types, the number of computers used and their relative position in the working environment;

• Critical Process 2 describles the relationhip between the number of computers used to run the courseware for a class group and the courseware management strategies that teachers self-invoke.

A further two critical processes were identified that relate to the task/pedagogy features of the courseware trials:

• Critical Process 3 describes an emergent hierarchy of a task type match, a design brief frame match and a teaching approach match for the success of the courseware. It describes the consequences and and relative significance of matching these three criteria when teachers use this courseware.

• Critical Process 4 describes the relationship between the specificity of the given application context for the electronic componentry and the levels of heuristic courseware interaction. It goes on to describe how a bar is applied to the levels of heuristic interactions by control strategies invoked by teachers, in situations where there is a teaching approach mismatch.

The four critical processes identified can be seen as the answers, provided by this current research project, to research questions 6 and 7.

Chapter 6 - Recommendations for the Next Courseware Iteration

This chapter develops three major themes, identified as a result of the discussions in chapters 4 and 5, that relate to the possibility for further development in both courseware content and operation. These themes can be seen as the answers to research question 8.

Two of these themes relate to courseware control:

• Cluster transition and the ability to back navigate between cognition clusters - The possibility of providing dynamically updated maps as either front-end, back-end or overarching utilities is discussed in terms of system overhead and the effect upon users' interactions with the courseware. All three options are subsequently discounted, but, by their discussion, the potential to enable a dynamic map that is invested with the same level of intelligence exhibited by the courseware emerges. The proposed map would derive its intelligence from the user model and have the capacity to dynamically update it. Its operation and appearance is described in terms of rule-based extrapolation from the user model data.

• Cluster 2 concurrent visit strategies (C2-CV) - A modification to the control of congnition cluster 2 is proposed to enable it to be completed in one visit rather than the minimum three in the current version. Cluster 2 is where information about the three circuit stages is accessed. This modification is proposed in light of high courseware completions by teachers who invoked a C2-CV strategy with their pupils. However, this strategy was only successful when computer time is limited and the critical processes are favourable.

The third theme relates to courseware content:

• Application Specificity - Critical Process 4 describes a link between the levels of heuristic interaction with the courseware and the levels of specificity of the application

context given for the electronic componentry, particularly in relationship to the input excursions in cognition cluster 1. The proposed modification would make this information more generic at the current level and then to add a hierarchically organised set of example application contexts. These exemplars would apply the previously supplied generic information to show how the circuit configuration operates in the range of given application contexts.

Chapter 7 - Conclusions and Recommendations for Further Work

This chapter provides the conclusions that can be drawn from undertaking this current research project. It summarises the effectiveness of the project methodology, the analytical method and the efficacy of the courseware. It goes on to describe the two significant contributions to knowledge that this current research project makes claim to. These contributions relate to the courseware development paradigm and the four critical processes that arise from its trials.

As a result of this research project, and the insight gained from undertaking it, it has been possible to identify four significant areas for further research, which are the answers to research question 9. The first three of these areas relate to progressing the courseware from a prototype to a useable product. Individually they are:

• A need to investigate the relationship between content and structure in the courseware and to investigate how these two components might usefully be separated. Such a separation should enable rapid repurposing of courseware and a reduction in the number of 'nodes' that it need contain in its knowledge domain.

• A need to increase the robustness of the courseware prototype to prevent corruption of the user model data. The user model is a critical component in maintaining the intelligence of the courseware and , as such, it has to be protected from corruption if the courseware is to remain productive for its users and a positive asset to the teachers who deploy it.

• A need to investigate how the user model data can be networked. Such a distribution would enable the intelligence of the courseware to be distibuted and free it from being machine dependent. A further significant pay-off from this development would be the possibility of porting courseware, instantiated using this development paradigm, to web servers accessed via the Internet.

The final area identified for further research relates to users' interactions with the courseware. A key feature of learning resources developed for users in design-led situations are their ability to stimulate interactions on a heuristic level. This heuristic interaction is a feature that can elevate intelligent courseware above traditional texts. Although there were very favourable qualitative indicators from the participating teachers, the quantitative indicators show that this courseware prototype has failed to achieve this to any significant extent. However, critcical process four, that relates to heuristic interaction with the courseware, lends useful insight into how this subsequent area for further research might be approached.[8]

References:

Phillips. M. and Pugh. D. (1994) - How to get a Ph.D. : A handbook for students and their supervisors - Open University Press: Buckingham (Second Edition)

Robson. C. (1993) - Real World Research: A Resource for Social Scientists and Practitioner-researchers - Blackwell: Oxford

[8] Critical process four is fully described in Chapter 5 of this thesis.

Chapter 2 - Defining the Problem and Proposing the Solution

Section 1 - From Here to Uncertainty

*We drank Tabs and idly slagged interactive CD technology (Todd: " I used
the Philips CDI system - it's like trying to read a coffee table book with all
of the pages glued together.")*
Coupland. D. 1995 p.30
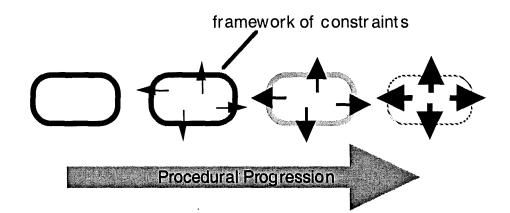
Design and Technology teaching is operationalised by children engaging in task

directed, goal oriented activities that result in product-based outcomes. (DFE 1995,

Eggleston. J. 1992 p. 2-11, Kimbell. R. 1994a p. 241-256)

These activities and outcomes are structured by the Design and Technology 'project'

which has become the principal method by which teachers deliver the curriculum in a

progressive way; successive projects focusing upon areas of the subject that are new to

the pupil. A secondary progression is evident in the pedagogically effective project

format, in that their structure leads towards greater procedural autonomy in the pupil.

Ever increasing levels of responsibility and control of the activities and outcomes of the

project are placed upon the pupil as the teacher withdraws their own control and

constraints.

This progression in pupil's procedural autonomy is described by Kimbell, who provides

this model (Kimbell. R. 1994a p. 245),

framework of constraints

The framework of the task becomes increasingly permeable

Fig.1

The progression in subject knowledge and procedural autonomy engendered by

teachers, and exhibited by pupils, is referred to as Design and Technology capability; a

concept first described by the working group for National Curriculum Design and

Technology in their interim report of 1988. Its analysis of how progression in this

capability is engendered being principally based upon the context within which the

activity is set.

> *As the range of contexts in which design and technological activity is*
> *embedded becomes broader, so the demands for knowledge, skills, personal*
> *qualities and judgment in the field of values will expand progressively over*
> *the four key stages.*
> (DES 1988 p. 18)

Doherty, et.al. describe capability as the capacity to interrelate the What, Why and How

of design and technological activity.

*...if the concepts of how, what and why are developed separately they foster
ability. This ability can be to a very high level, but if the concepts are
developed in such a way that the interrelation is enabled then capability is
achieved... We must guard against giving children experiences that are
narrow and prescriptive ...The way into this is to identify and understand the
concepts that underpin the way in which children manage and develop that
management of the Design and Technology procedures. The development of
programmes of work that target a focus for activities which contribute
individually to a collectively structured experience is the way to
progressively develop capability.*

(Doherty, et.al. 1994 p. 115)

Patterson provides further insight and describes this process as a 'teaching continuum'.

He expresses and qualifies it thus,
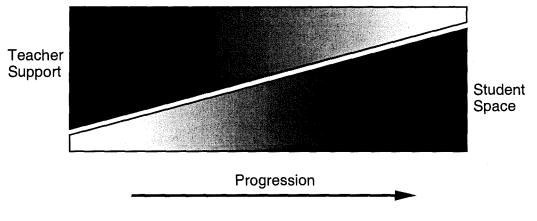
Fig. 2

*For this continuum to work a teacher needs a repertoire of activity and
experience to ensure that an individual student has an appropriate balance
of space and support needed for progression. A repertoire includes a range
of resources, strategies, content and the means to respond to changing needs
and demands. It implies confidence in the management of the learning
environment.*

(Patterson. J. 1994 p. 58)

Patterson's continuum is formulated within the context of Information Technology, but its relevance to Design and Technology is evident. The qualifying criteria are not inconsiderable; particularly when applied to the subject of Design and Technology, which requires in-depth knowledge of a number of individual disciplines. For a teacher to effectively manage a learning environment, that is structured by these concepts of progression, they must possess a good level of competence in these disciplines. If there are gaps in the teacher's capability then the progression of procedural autonomy in the pupils, the passing of control to engender capability, will be compromised.

Such a situation is likely to lead to the polarisation of activities, in that they will reside at one extreme of the continuum. Too much control retained by the teacher leading to activities more akin to handicraft, with the teacher in sole control of the design, manufacturing processes and, in effect, the essential essence of the project; too little control resulting in pupils, with insufficiently developed capability, being swamped by the number and magnitude of the design decisions to be taken, leading to effective teaching and learning opportunities being lost.

This research focuses upon one area of the Design and Technology curriculum in which there are implicit problems; that of electronics. Few, but the most recently qualified of Design and Technology teachers, have ever had training in this subject area; the DATA survey of 1993 showing that 67% of the sample group of Design and Technology teachers had no training in electronics and that 26% of the sample group had resorted to teaching themselves in order that they could teach it. (DATA 1994 p. 36 & 49)

Moreover, the subject area does not lend itself to ready access and its present provision

is in many ways reliant upon subject knowledge having been acquired externally, e.g.

through previous industrial experience; the same DATA survey showing that those

teachers most happy with their training and ability to teach the required components of

Design and Technology were those that had gained vocational qualifications followed

by a B.Ed. (DATA 1994 p. 61)

Tizard & Martin provide further insight,

> *Electronics is not being widely used in schools as a medium for Design and*
> *Technology. Despite a growth of electronics work in schools in the eighties,*
> *the introduction of the National Curriculum seems to have pushed*
> *electronics back into the science department. Talking to teachers it would*
> *appear that there are two main reasons for this. The first is that electronics*
> *is an area of knowledge that many teachers feel uneasy about their own*
> *ability to deliver. The second is the pressure of time schools are under, and*
> *the difficulty of a group of mixed ability children being able to realise any*
> *significant outcomes in the time that might be available for an electronics*
> *project.*
>
> (Tizard. J. & Martin. J. 1992 p. 1)

These problems of lack of in-depth subject knowledge and available time are

compounded by much of the resource material that is available. Many of the commonly

used text books that concentrate specifically upon electronics, or the 'catch-all' Design

and Technology tomes with sections on electronics, do not always reflect the nature of

contemporary design and technological activity. There is either an overbearing and

unnecessary concentration upon the functioning of the circuitry, or they supply ready-to-

use recipe circuits that leave no opportunity for children to make design decisions about

the componentry. In order to support a progressive approach to capability, the resource

material should reflect the concepts of the previously described continua and provide a framework, whereby the teacher can pass control over the activity to the pupils, to levels that are appropriate to their developing capability. This framework that structures the resource material is its pedagogical underpinning.

Some of the more recently available resource material begins to address this problem by propounding a 'systems approach' to electronics; a concept that is embedded within the current version of the national curriculum. This approach divides electronic circuits into simple system blocks that have a unitary function; principally three - input, process and output. When appropriately combined they form the functioning circuit. This approach aims to allow children to take a macro view of the system and enable them to 'design' functioning circuits.

The major pedagogical issue highlighted by this systems approach is the suitability of the componentry that is contained within the system blocks. In considering a 'process block', it could contain a plethora of different devices that enable it to function in an appropriate manner. These could range from simple bipolar transistors, through to operational amplifiers, dedicated integrated circuits and even digital microprocessors. It is evident that a simple macro view is not appropriate when developing capability is taken into account. What is needed is a range of systems approaches that, ...*target a focus for activities which contribute individually to a collectively structured experience ...to progressively develop capability.*

(Doherty, et.al. 1994 p. 115)

The major thrust of this current research is to provide resources for the teaching of electronics within Design and Technology in secondary schools. The proposed delivery platform, that of hypermedia based courseware, aims to investigate an alternative paradigm to text books for the facilitation of this subject area, that can address the issues of developing capability, increasing levels of procedural autonomy in pupils and the support of teachers in the release of control to pupils. An essential aspect in the development and subsequent use of this resource is, therefore, the interaction between the learner and the teaching content and the extent to which control can be transferred from the teacher to the pupil through the medium of the courseware.

At the inception of this project it was necessary to take some pragmatic decisions regarding the range and scope of the work, enabling completion in a reasonable time-scale and within the developmental model of individual author prototyping (Phillips. W. A. 1990 p. 9 - 15).

The following decisions concerning the nature of the resource were taken:

1. The courseware would aim to facilitate the completion of a single Design and Technology project. The project should be familiar to a significant number of Design and Technology departments in schools to maximise the number of potential trialing environments.

2. The nature of the project chosen would determine the age of the children at which the resource would be aimed. It was decided that the most appropriate age group would be year 9 children allowing for a reasonable level of complexity to be explored. It was felt that this would also contribute to the willingness of schools to trial the material when they are necessarily protective of their examination groups.

3. It was necessary to choose a development platform that was flexible enough to provide a 'multimedia', interactive interface and that was accessible enough to allow the authoring and programming to be carried out by the researcher. This precluded the use of the typical range of application development languages, as the time needed to acquire sufficient programming skills would be excessive. It was decided, therefore, that the most appropriate development platform would be the use of HyperCard on the Apple Macintosh.

Hypermedia - Some definitions

The term hypermedia is a construct of hypertext and multimedia. As a paradigm for computer software engineering, hypermedia is a network of information 'nodes' with 'links' between the nodes. Hyper refers to the linking structure which can be traversed in a non-linear and interactive way; media refers to the information contained within the nodes which can be text, graphics, sound, animation and video. Hypermedia uses the referential linking structure of hypertext which is augmented with a richer source of media. Multimedia exhibits the rich source of media yet does not necessarily use the referential linking structure of hypertext. As a set, hypertext is a subset of hypermedia which is a subset of multimedia.

(Woodhead. N. 1990 p. 2 - 4)

The environment that is created by the hypermedia is often referred to as a 'hyperspace'. Users move around the hyperspace using a variety of strategies, principally:

• Browsing - a non-directed wandering through the information nodes with serendipitous path experiments. It concentrates on the micro features (information nodes) of the hyperspace.

• Navigating - a purposeful movement through the hyperspace concentrating on the macro features (link structure) of the hyperspace.

(Woodhead. N. 1990 p. 102 - 103)

Hypermedia is a relatively new and developing paradigm. It forms the basis of contemporary developments such as many CD-ROM interfaces and the World Wide Web.

As a concept, the beginning of hypermedia is attributed to the 'memex' system of Bush in the mid 1940's. He envisaged a system that would, ... *support (the) selection of information by association rather than by indexing... using the technology of the day, ...microfilm, facsimile, photocell and telegraph, with information stored in a desk and accessed by means of levers.* (Woodhead. N. 1990 p. 5)

The development of computer technology has led to the realisation of Bush's concept, but it was not until comparatively recent times that hypertext, and its offspring hypermedia, came into the realm of the larger public; this being predominantly precipitated by the release of Bill Atkinson's HyperCard for the Apple Macintosh in 1987. Atkinson describes his program as, *...a software erector set* (Salkind. N. J. 1991 p. 738). It combines the user interface of the Macintosh with powerful multimedia authoring tools and a high-level, object oriented programming language known as HyperTalk. A compelling and potent combination regarded as, *... a milestone in the history of computing*, and *...a shift of paradigm in educational software.* (Schulmeister. R. 1994 p. 15)

The Design Requirements

Effective courseware design relies upon the formulation of a sound rationale and associated specification. These will be dependent upon many considerations which include those of computer science, cognitive science, knowledge engineering, technical authoring, hypermedia programming and others. Within the stated model of individual author prototyping some perspective needs to be brought to bear on this unmanageably diverse set of disciplines.

This is not unreasonable or detrimental as Woodhead explains,

> *There are two possible answers to the question of what specialist knowledge is needed by hypermedia authors and developers:*
>
> *• A great deal: as in knowledge engineering, a multi-disciplinary awareness is probably desirable.*
>
> *• Very little: packages are relatively easy to learn with a small kernel of commands and strategies; there is no need to be completely right first time - incremental prototyping is feasible, and probably even desirable.*
>
> *...Wherever possible, it is desirable to work from elicited user requirements, using an iterative, incremental process of validation and modification.*
>
> (Woodhead. N. 1990 p. 99)

This research is set within a very particular context and it is this context that has the overarching influence over the design of the courseware. This rationalisation leads to three primary design considerations: the situation in which the courseware will be used; the task that the courseware will be used to support; the pedagogy that the courseware will reflect and support. The three considerations are interrelated in the development of the courseware rationale and the formulation of its associated specification.

The Situation

In considering the situation this is perhaps the area that is least open to debate, or the proposition of alternative solutions, as it is firmly structured by pragmatic decisions. However, these pragmatic decisions will have some effect upon the operation of the intended courseware.

Design and Technology activity, the undertaking of projects, principally takes place in Design and Technology workshops. There is a considerable variance in the facilities that these workshops provide across the spectrum of secondary schools. In the time period that this current research project took place, many schools did not have ready access to networked computing facilities from within the Design and Technology department. The hypermedia resource aims to explore an alternative to the use of textbooks and other written materials in providing information to facilitate the project. Moreover, it looks to assess the levels to which control of the activity can be passed from the teacher to the pupil though the medium of the courseware. It is evident that the courseware should be situated in the workshop in which the activities will be undertaken, allowing children to have ready access to it, instead of time-tabled exposure in dedicated IT facilities. As Smith confirms in his report on the DFEE, DATA, and NAAIDT consultation conference concerning the use of IT in Design and Technology teaching and learning:

> *Ready access by pupils during their D&T lessons to sufficient hardware and software is essential. Access to computers depends not just on the number available but on their location and the management of them*

(Smith. J. S. 1994a p.10)

The design of the courseware must enable it to be effectively used within such situations, where it is unlikely that there will be large numbers of individual computers. It should be designed to allow it to be used by an average class size, from one or two computers within the Design and Technology workshop. Designing courseware that engages children for long periods of time before the necessary information is gleaned would not be effective in this situation. Moreover, if the resource were to allow completely unstructured browsing, or information 'grazing', then bottlenecks in the access to the resource will result and the natural curiosity of children wishing to explore the hyperspace could, perhaps, lead to computer assisted 'poggling' (Kimbell, R. 1994b); a situation where pupils are seemingly on-task but are making no forward progress.

This approach does not, however, advocate the restriction of the hyperspace to simple linear navigation processes with the computer doing the 'page turning', but a structured approach that is at an appropriate point between the two extremes. As Hutchings et. al. suggest,

> *The benefits of learner control afforded by hypertext and hypermedia*
> *systems are persuasively championed by hypertext advocates, but all too*
> *often this hides an assumption that the goal of learner understanding can be*
> *equated with the goal of information provision. If learning also needs*
> *thought, then it is often the case that more explicit direction and control, to*
> *restrict the learner to realistic goals and to a sensible part of the knowledge*
> *domain, needs to be judiciously mixed with freedom of action.*
>
> (Hutchings. G. A. et.al. 1992 p. 173)

The structuring and control of the interaction with the courseware will initially be shaped by the pragmatic organisational considerations brought about by the situation, but the finer detail can only be provided by the interdependent link between the task that is set and the pedagogy that is applied within this situation.

The Task

The task that the courseware will be used to complete is a Design and Technology project at Key Stage 3. For the courseware to be effective it must be an attractive asset to teachers. Practical guidance offered by Cates includes suggestions that such material should:

> *1. Match current curricular emphases;*
>
> *2. Match current teaching practice;*
>
> *3. Match current instructional time restraints.*
> (Cates. W. M. 1992 p. 5 - 6)

Cornail-Engel summarises teachers' willingness to introduce technological innovations by the criteria that they will:

> *- be easy to use, and once in use the technologies will not be being constantly renewed,*
>
> *- fit in well with the teaching methods which have been tested and are valued,*
>
> *- allow the desired objectives to be achieved.*
> (Cornail-Engel. I. 1994 p. 251)

In contemporary Design and Technology many of these considerations are structured by the National Curriculum; the current version of which gives clear guidance as to the nature of 'systems and control', the subject area principally concerned with electronics. (DFE 1995 p. 8.6)

In selecting the task, or project, that the courseware will facilitate it is necessary to choose one that reflects current practice in this area, that conforms to the relevant programmes of study in the National Curriculum and that includes the concepts of developing capability and procedural autonomy in the pupils. As these criteria are somewhat general, the final decision is commensurately arbitrary, but a good fit is the design and manufacture of a simple alarm system based around the use of a thyristor. This project will be familiar to many Design and Technology teachers and, if sufficiently resourced and supported, allows pupils to make significant design decisions by choosing from a range of input and output componentry to suit their product to a specific context. This level of teacher control of project outcomes, balanced against pupil choice of the products' functioning and application context, implies a framed task in the mid regions of the previously described continua.

The notion of the framed task is provided by Kimbell, et.al. in describing a hierarchy that resulted from the work of the Assessment of Performance Unit (APU) work into Design and Technology. They use this hierarchy to categorise the nature of tasks and state,

> *The APU data demonstrated that the subject matter of the task (e.g.*
> *electronic alarms or fabric constructions) counts for relatively little in*
> *determining how well pupils are able to perform. But it matters a great deal*
> *whether the task is set loosely or tightly.*
>
> (Kimbell. R. et, al 1996 p. 12)

The resultant hierarchy of tasks is stated as:

- *Contextual task: very open*

- *Framed task: some constraints*

- *Specific task: tightly defined*

These classifications represent the two end points, and one mid point, in a continuum

which they also specify as ranging from particularised tasks to generalised contexts.

Furthermore, they recognise the interrelationship between these activities and the

possibility for, and desirability of, movement up and down the hierarchy in either

direction from a given starting point or design brief. In defining where this starting point

should be they offer arguments as to why it should vary from task to task. These

arguments are principally concerned with developing capability by enabling pupils to

respond effectively to differing levels of specificity of brief and to compensate for the

differing performance of pupils from a given starting point. It is salient that the APU

data showed that generally girls do better than boys when tasks are loosely defined and

boys do better than girls when tasks are tightly defined (Kimbell. R. et, al 1996 p. 94).

However, they state that the task entry point was most often somewhere in between

these extremes, and that pupils should be encouraged to move up and down the

hierarchy to explore the general context and define for themselves a particular task.

They represent the hierarchy diagramatically thus,

generalised context

layers
of tasks

Particularised task
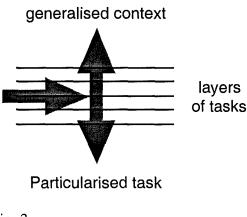
Fig. 3

(Kimbell. R. et, al 1996 p. 41)

The efficacy of this movement up and down the hierarchy and the importance of the

interrelationship between the two end-points, viz. contexts and specific tasks, is further

illuminated by their views on them.

On contexts,

> *Real tasks do not exist in vacuo... and the setting of the task is a major*
> *determinant of the meaning of that task. If you were invited to design a door*
> *handle it would have very little meaning until you could see the context for*
> *which it was intended.*
>
> (Kimbell. R. et, al 1996 p. 11)

Furthermore,

> *...contextualised tasks provide richer learning experiences for children. This*
> *is for two reasons. First, because the context provides meaning for the task*
> *and second because it provides (in a very concrete manner) a series of*
> *trigger points for action... Contexts are enormously empowering for*
> *teachers and pupils alike*
>
> (Kimbell. R. et, al 1996 p. 12)

However, this does not suggest that all tasks must have a contextual, open-ended,

starting point, but that tasks should be set in context, or the context explored, to give

meaning to the product and to augment pupil progress. Products need end users and end

users exist in a context. If the context is not considered, in a tightly specified task, then

the outcome of the activity is difficult to describe as a product ; more easily as an

unjustified, or externally justified, artefact.

In considering tasks Kimbell, et.al. identify, then rationalise, the paradox of pupils learning Design and Technology by undertaking technological tasks that result in products. Developing products in a technological context demands activity that is at the far right of the previously described learning continua and the ability to move fluently up and down the hierarchy of tasks. However, they put forward the view that tasks have a dual purpose in that they not only exist as opportunities to develop products but that they also provide teaching and learning opportunities. They express this duality of purpose in a continuum thus,

product
purposes

constraints applied
by the client
and/or
the user

Constraints
applied by the
teacher

teaching
purposes

A project in which
user constraints
are the dominant
influence; little
teacher control.

A project in which
teacher
constraints
are the dominant
concern; little
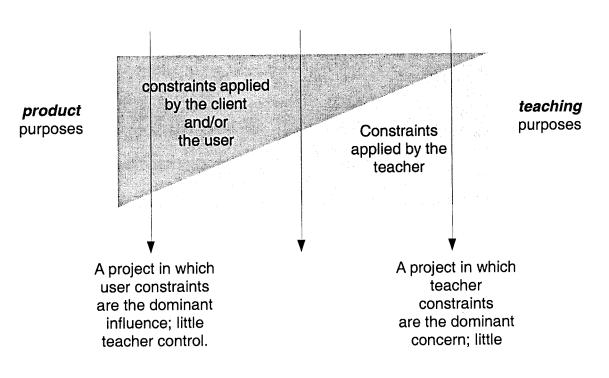
Fig. 4

(Kimbell. R. et al 1996 p.37)

If a specific task, or range of tasks, is to result in a product then the client, user or

context in which they exist must be considered and have some influence on the

outcome. Specific, closed tasks may not naturally lead to these considerations as they

can be completed in vacuo. Conversely, an investigation of an identified client, user or

context in which they exist may lead towards a specific task that results in a product, but

the teacher may have little control over the nature of that product or the taught content

that is necessary to support the activity. So, the interdependency between the two end-

points of the hierarchy of tasks is evident in the process of successful product

development and the framing of the task, and the entry point in the hierarchy, is the

mechanism by which the teacher might control this activity and structure their teaching

input.

So what of the nature of the frame? In Kimbell's model for progression in procedural

autonomy (page 2), his indicator of capability is characterised by the permeability of the

task framework. In applying this model to the hierarchy of tasks it is again evident that

the logical starting point for the task still tends towards the mid, framed, point, but that

the constraints applied by the frame should be gradually reduced to enable pupils to

traverse the hierarchy to greater heights and depths. However, this simple synthesis

assumes that the breadth of the hierarchy remains constant. It is in the breadth where the

complexity also lies and, necessarily, the higher orders of capability are exercised.

The role of the breadth of contexts in relationship to the development of capability has

already been alluded to by reference to the National Curriculum working group's

analysis of how this development of capability might be achieved.

> *As the range of contexts in which design and technological activity is*
> *embedded becomes broader, so the demands for knowledge, skills, personal*
> *qualities and judgment in the field of values will expand progressively over*
> *the four key stages.*
>
> (DES 1988 p. 18)

The significance of this statement now becomes more apparent. It further establishes the interdependent link between the end points of the hierarchy of tasks and confirms the need for increasing breadth. As a context becomes broader the level of knowledge, skills and judgement used in the derivation and completion of specific tasks increases commensurately and, with reasonable extrapolation, that an increased level of knowledge, skills and judgement will enable a context to be utilised more thoroughly. So it becomes increasingly evident that the controlling mechanism over the breadth of the hierarchy of tasks, the resultant activity in the studios and workshops and the structuring of teaching is the framing of the task.

The models discussed are useful in describing how Design and Technology capability might be developed, how tasks might be set, and how pupils might be encouraged to work, but, for the purposes of this investigation, they do not put sufficient emphasis on the framing of a task and its interrelationship with developing capability; where capability can be seen as the process of passive recipients making artifacts being developed into active participants who design products. The framing of the task has particular significance to this research in that if, as has been discussed, there is an interrelationship between the frame and the structuring of the teaching then there must also be a corresponding relationship between the framing of the task and the resource material that is used to support its teaching.

Such a model would need to encapsulate the notions of broadening contexts and frames, and to make the hierarchy of tasks, and its subsequent enlargement, implicit within the frames. So in considering a single frame its perimeter controls the length and breadth of the hierarchy of tasks. The smaller the frame, the less capability is required and the more control is exerted by the teacher. Generalised contexts and specific tasks are more

closely situated enabling easier traversal of the hierarchy and reducing the number of

task entry points. The breadth of the hierarchy is reduced to commensurately reduce the

number of design decisions to be taken. As the frame gets larger, more capability is

required and less control is exerted by the teacher. However, control is not completely

relinquished. Generalised contexts and specific tasks become more distantly situated,

which requires greater capability to effectively traverse the hierarchy and introduces a

greater number of task entry points. The breadth of the hierarchy is increased, which in

turn increases the number of design decisions to be taken, with a commensurate increase

in the range of possible outcomes.
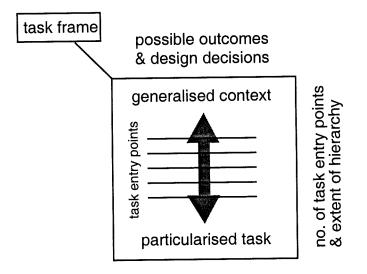
Fig. 5 - Applying a frame to the hierarchy.

Developing the model from a single frame, or project, into a teaching continuum then

becomes a matter of reiterating it in ever broadening forms, as shown in figure 6.

Product

task frame

possible outcomes
& design decisions

generalised context

task entry points

particularised task

no. of task entry points
& extent of hierarchy

Artefact
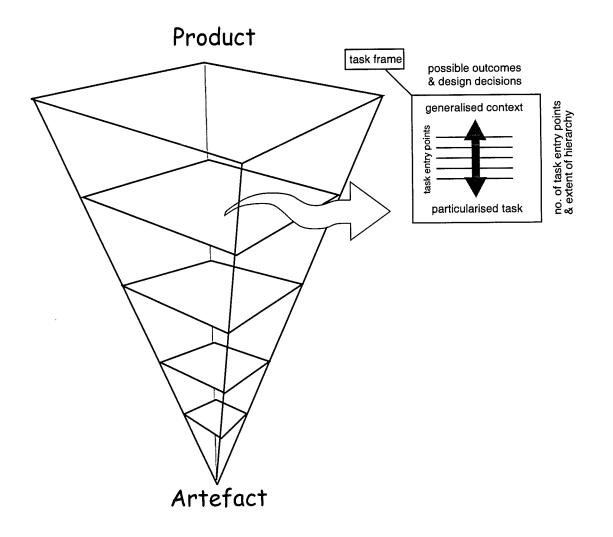
Fig. 6 - Reiterating and broadening the frame to formulate the continuum.

It is unfortunate that the model is complex, but the situation it represents is complex too; perhaps more so. It is also evident that there will always be scope for further debate regarding the semantics and operationalising of Design and Technology as a school subject and that models can potentially be formulated and reformulated ad infinitum. However, what this model enables is the formulation of strategies to teach a very specific element of the Design and Technology curriculum, i.e. electronics, in a way that enables it to contribute to an effectively framed brief rather than being seen as an end point in itself, and moreover, to design resource material that will enable pupils to traverse the hierarchy of tasks when working specifically with the electronic circuitry.

The significance of this strategy can be made clearer by the use of examples to construct a taxonomy of task types:

Task Type A - make this circuit.

Teaching is initially targeted at a particular circuit with given components; the task entry point is at the bottom of the hierarchy. If successful, theoretical knowledge is passed to the pupil and they build the said circuit. The task can be set within a complete design brief, e.g. Design a plant pot moisture tester/alarm. The opportunity to fully satisfy the brief, by the effective traversal of the hierarchy of tasks, is open to much of the work **except** for the electronics.

Task Type B - make a circuit.

Teaching is initially targeted at a particular context; the task entry point is at the top of the hierarchy. There is a given need for pupils to undertake some electronics as this is an electronics project! Either pupils investigate the context, traverse the hierarchy and derive a specific task which then requires them to find an appropriate circuit, or they find a circuit that interests them, or seems to have potential, then apply it to the context.

In both cases the circuit is a 'recipe'. Unlike in type A task the teacher will find it difficult to integrate the teaching of electronics in a context sensitive manner or to make their input relevant to all of their pupils, unless the situation is very carefully stage-managed. Again, the opportunity to fully satisfy the brief, by the effective traversal of the hierarchy of tasks, is open to much of the work **except** for the electronics.

Task Type C - design a product that...

Teaching is initially targeted at a particular circuit configuration that performs in particular ways, but that has optional elements. In attempting to satisfy the given brief pupils are given the necessary impetus to go up the hierarchy to investigate or identify a context in order that they can select the appropriate options. And, subsequently, to then go down the hierarchy to crystallise this combination of concepts and components into a working circuit. The teacher can now target their teaching at a recognisable and reasonable range of options which are centred around a common circuit configuration, making it relevant to all pupils and building a base of theoretical knowledge that can be exploited in subsequent work. Now the opportunity to fully satisfy the brief, by the effective traversal of the hierarchy of tasks, is open to all of the work **including** the electronics.

A type C task gives a basic structure for framing a project brief and setting tasks within that brief and, in the example given, bases this structure around a circuit configuration. What remains to be determined is the nature of a 'circuit configuration' and the relationship between a project brief, framed by the structure of task c, and the reformulated teaching continuum (page 40). Essentially, how is progression introduced into this structure?

Again it is necessary to recognise that the National Curriculum will have the overarching influence upon the nature of the principles and concepts that will be taught within this element of the Design and Technology curriculum, but that the content of individual tasks, although conforming to this guidance, is largely left for teachers to formulate for themselves. The concept of a systems approach to electronics has already been introduced (page 25) and the role of the teacher in deciding the content alluded to in the discussion of the 'process block'. So a 'circuit configuration' could be decided by the choice of componentry in the process block as in the project chosen for this research. Perhaps this is the most straightforward method of working within the structure given by a type C task. The process block is decided upon, its operational characteristics are used to frame the brief, set the task entry point and provide limits to the length and breadth of the hierarchy of tasks. Further control is afforded by the choice of input and output componentry that is made available. It is evident though that starting points for the framing of a task could be focused upon other system blocks and still be effective within the structure given by a type C task. It could be that the output block is decided upon and the focus for the brief is in designing ways that this might be energised or that the input block is decided upon and the focus for the brief is in choosing or modifying the input componentry to suit it to the intended application or, in fact, many other initial foci. However, the apparent focus for activities for the pupil may appear to change, but the framing of the brief by the teacher always returns to the process block. It is this block that is at the heart of the system, or circuit, and it is this block that will be most influential in setting the operating characteristics of the circuit. So, making a frame wider in a project that involves work with electronics relies upon the selection of the process block by the teacher. This is what is meant by a 'circuit configuration'. Progression and the effective framing of the brief relies upon the careful selection of this 'circuit configuration', which is essentially decided by the process block.

So in referring to the National Curriculum for Design and Technology, to structure the teaching of this aspect of the subject, in order to teach pupils how:

> *... to use electrical switches to control devices;*
> (DFE 1995 p. 8.6)

we will not be using a process block at all. In this example structure the activity undertaken will be at the base of the teaching continuum (page 40) and perhaps tend more towards the artefact than the product. The activities are focused by the reduction in length of the hierarchy of tasks in that the application context and the particularised task are closely situated by the brief, e.g. a pocket torch, and the breadth of the hierarchy of tasks is limited again by the framing of the brief but also by the limitations applied by the available componentry. It should be noted that this activity could be applied further towards the end of the teaching continuum and the design of the switch could form the basis of a significantly high order piece of industrial or engineering design work and considerations such as this could be applied to other cited examples in this structure. In order to teach pupils how:

> *...to use sensors in switching circuits (and) ...that systems have inputs,*
> *processes and outputs, and to recognise these in existing products and*
> *products that they have made;*
> (DFE 1995 p. 8.6)

we will select an appropriate process block to enable the use of simple sensors. This might be achieved by basing the work on bipolar transistors or thyristors. The frame is widened by the range of applications that the system can be applied to and the work begins the transition from artefact to product by the necessity to further consider the application context and hence the user. The application context and user considerations can also be exploited in bringing meaning and significance to the other tasks undertaken in completion of the brief, e.g. the form of the case parts, the chosen method of

manufacture, the introduction of anthropometric and ergonomic considerations, etc. In order that pupils can begin:

> *...to analyse the performance of systems, in order to check that they are working effectively;*
> (DFE 1995 p. 8.6)

we might introduce the operational amplifier to overcome the problems of inaccuracy and hysteresis brought about by the use of a singe transistor. The frame is widened again by encouraging the further consideration of users needs and performance in the applied context. This will allow us to begin teaching about the concept of feedback in controlling the gain of the amplifier and, in so doing begin to address:

> *...the importance of feedback, and how it can be used to ensure the correct functioning of mechanical, electrical or electronic systems;*
> (DFE 1995 p. 8.6)

we might then introduce logic gates to enable combinatorial systems that can respond to user input, sensor input and/or feedback signals. Again the frame can become wider as the breadth of application contexts and particularised tasks is increased and they are more distantly situated. It should be noted that this example structure is couched in optional terms as other routes could legitimately be taken. However, what this structure illustrates is that by framing briefs within the structure defined by a type C task and by basing the selection of circuit configurations upon the process block, it is possible to design tasks that enable pupils to be given coherent task entry points that enable an appropriate traversal of the hierarchy of tasks, that have the concepts of progression inbuilt and that, *...target a focus for activities which contribute individually to a collectively structured experience ...to progressively develop capability.* (Doherty, et.al. 1994 p. 115)

In facilitating this approach the participants, teachers and pupils, will require resource

material and this discussion is focused upon the nature of the material. In discussing this

further it is useful to revisit the earlier premise:

The framing of the task has particular significance to this research in that if, as has been

discussed, there is an interrelationship between the frame and the structuring of the

teaching then there must also be a corresponding relationship between the framing of

the task and the resource material that is used to support its teaching. (page 38)

This research aims to develop hypermedia based courseware and the task considerations

so far have begun to justify a role for this courseware in supporting a given task.

However, in justifying the legitimacy of the selection of hypermedia based courseware

over traditional texts it is necessary to continue this debate further.

Which ever extant model for the process of design is examined there is always a need

for information to enable progress. Sources for this information will be wide ranging

but in the school situation, where it has already been ascertained that tasks will have

both a product purpose and a teaching purpose (See fig. 4), some of this information

will be established theory and 'look up' data from textbooks, essentially the knowledge

base of the subject. How this information should be structured, when it should be

consulted and how it fits into any of these models is either unclear or unspecified and,

hence, there is a need to establish what the interrelationship between the process of

design and the consultation with the knowledge base is, particularly in a teaching

situation and when the progression in pupils' procedural autonomy is a central aim.

The principle problems with the extant models is that they attempt to represent the

practice of design rather than the teaching of design and, in order that they may be

readily understood, they are often overly simplistic, which can have negative

consequences upon both practice and teaching. This phenomenon is explained by

Shepard:

> *In too many schools over the past twenty years the design process has come*
> *to be crudely understood and presented as a systematic, largely unrelated*
> *linear sequence of problem-solving activities. Although it is true to say that*
> *designers do work through some sort of structure... they certainly don't*
> *progress in a rigid, routine and neatly ordered manner. The process is much*
> *more complex even than the cyclic diagrams... In practice there is a*
> *constant interplay between each of the skills, with a rapid changing of*
> *emphasis and frequent switching between developing broad concepts and*
> *detailing and refinement.*
>
> (Shepard. T. 1990 p.27)

This phenomenon brings the discussion back to Kimbell, et.al. as this 'frequent

switching between developing broad concepts and detailing and refinement' clearly

links to the traversal of the hierarchy of tasks between the contextual and the particular.

Returning to the work of Kimbell, et. al is perhaps unsurprising. As recently as 1988

Penfold made the often quoted assertion that:

> *Craft, Design and Technology is conspicuously the most under-researched*
> *area of the curriculum. Qualitatively and quantitatively, the surface has only*
> *just been scratched... the literature is virtually nonexistent.*
>
> (Penfold. J. 1988 p. 157)

The work of Kimbell, et.al through the Assessment of Performance Unit (APU)

(Kimbell. R. 1991) and Understanding Technological Approaches (UTA) projects

(Kimbell. R. 1994b) has been significant in overcoming this shortfall. However, no

complete model which relates the process of design to consultation with the theory is

provided by them, but a potentially useful starting point emerges with their explanation

of the iterative relationship between action and reflection in the completion of tasks.

> *In the test development phase of the APU project it became obvious that the best levels of pupil performance were associated with activities in which action and reflection were kept in balance. Design and Technology is about the active pursuit of real problems, but it must be focused and directed by continuous awareness of the needs to be met, the priorities of the users, and the strengths and weaknesses of the work so far. In a Design and Technology task... the relationship between action and reflection is iterative. Action forces issues into the daylight, and in reflecting on these issues, we raise further directions and possibilities for action.*

(Kimbell. R. et, al 1996 p. 13)

Hence, the interdependency between action and reflection in the completion of a task

might be illustrated by a simple model thus,

Outcome

Action ———————➤ Reflection
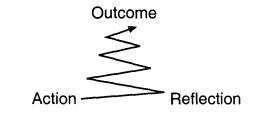
Fig. 7

In incorporating the knowledge base into this model it is necessary to identify how the

interdependency might operate. It is already established that the relationship between

action and reflection results in the ongoing evaluation and direction of the task.

However, it is reasonable to assert that pre-existing understanding of the knowledge

base will have a direct effect upon the initial actions relating to the completion of the

task and that actions will result in personal consolidation of the knowledge base.

Reflection may lead to the need to gain further insight via the consultation of the

knowledge base to inform further actions and consultation with the knowledge base may

lead to new responses. Hence, the relationship between action, reflection and the knowledge base can now be represented thus,

Action ←—————————→ Reflection

Outcome

Knowledge Base
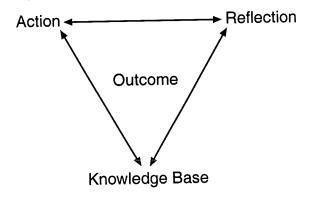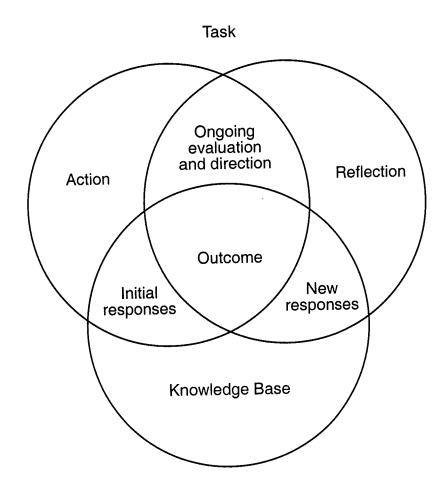
Fig. 8

and the interdependency defined by the overlap between the three constituents,

Task

Ongoing evaluation and direction

Action

Reflection

Outcome

Initial responses

New responses

Knowledge Base

Fig.9

In this model (Fig. 9) there is a recognition of the role of the knowledge base in structuring initial responses and in stimulating new responses to a task. In a teaching situation that aims to progressively develop capability the stimulation of new responses is a central tenet to success. Moreover, there is no separation of the knowledge base from the design process or implication that the knowledge base must be mastered before the design work can begin. Rather that the knowledge base has a central role to play in informing both the product purpose and the teaching purpose of the task. However, the efficacy of this relationship is reliant upon the qualities of the knowledge base utilised. If a task is to define the nature of the action, reflection and, hence, the new knowledge and understanding to be gained then the content of the knowledge base, and the way in which it is accessed, should also be defined by the task and by this interdependent relationship between action, reflection and the knowledge base.

The process of product development is set within a problem solving context and as Brown states,

> *...to solve problems one usually needs to acquire some new information. In most real life situations there is far too much information for any one of us to assimilate. What we do is to select, and our selection strategies will depend to some extent on what we feel we need to know...'*
> (Brown. G. 1995 p. 22)

The 'selection strategies' are key to the positive interdependency between action, reflection and the knowledge base as these strategies are an element of the control that is exerted by the teacher in the framing of a project brief. What emerges from this new model, for the interdependency between action, reflection and the knowledge base in the process of task completion, is a need for a continuum for the content and structuring of

the knowledge base to run in parallel with, or to be made implicit within, the teaching continuum for the framing of tasks. At the base of this continuum it is the teacher who will have most control over the content and structure of the knowledge base and as the continuum progresses and the frames get wider for that control to be gradually passed to the pupil. Furthermore, as the control exerted by the teacher is reduced and the task frames get wider then the content of the available knowledge base and the breadth of its coverage will increase commensurately.

In present practice the knowledge base is principally contained within, and drawn from, the textbooks that support the subject. The effective use of textbooks within the described continuum is initially heavily teacher dependent. A textbook in a standard codex form relies upon the expertise of the user to enable the positive interdependency between action, reflection and the knowledge base in a personalised, context sensitive manner. Hence, the teacher must initially 'decode' the text for the pupil, effectively 'hyperising' it by defining the linking structure between related sections to enable the effective sequencing of the material. It is possible to envisage a non-virtual manifestation of the 'hyperTextbook', and there is evidence provided by the quantity of worksheets and handouts provided by teachers and the increasing availability of photocopy free textbooks, but the management of such resources and their effective use are again heavily teacher dependent. Only hypermedia presently has the ability to structure a knowledge domain in sufficiently interactive and context sensitive forms to enable the effective interdependency between action, reflection and the knowledge base on an individual level. However, providing raw content in a hypermedia environment may be no more efficient than doing so in a textbook. The task is a major factor in the successful design of the courseware. To have such a clearly defined scope and range for the courseware overcomes many of the typical problems in the design and subsequent use of hypermedia based resources.

As Thimbleby explains,

> *Users 'get lost in hyperspace' because authors don't make good hypertext documents; they don't make good documents because it is difficult to do so; and there are no powerful tools to help them control the complexity of the design problem. Without adequate management of the design process, the task fit of a given hypertext document is a matter of chance.*

(Thimbleby. H. 1995a)

Thimbleby gives this explanation in the context of authors producing hypertext (or hypermedia) documents for an unknown audience, who will require different, and unpredictable, interactions and outcomes from the document. However, in the very particular context in which this research is set, the 'powerful tools' are not computer hardware or software but the very nature of the Design and Technology task itself. The ability to be able to clearly define the task and predict, with some confidence, the nature of the users' interactions with the courseware and the information which they will require to retrieve from it, enables the 'task fit' of the courseware to be firmly established from the outset.

As McKnight et. al. concur,

> *If hypertext is to achieve its potential, we must repeatedly remind ourselves that the user has a job to do, and design the technology to support the task.*

(McKnight.C., et. al. 1989 p. 173)

The Pedagogy

The forays of hypermedia into the world of education have been catalysed by this new paradigm for the access, linking and relating of information; that of a referential 'node' and 'link' structure. Jacobs writes,

> *From an educational standpoint, the principal attraction of hypermedia is that it lends itself naturally to non-sequential educational approaches, since it encourages the free-association characteristics of human thought. It enables the learner to choose his or her own direction while browsing through an electronic book, for example, moving from one knowledge domain to another in a smooth process of information-seeking and exploration.*
>
> (Jacobs. G. 1992 p.119)

In his paper Jacobs highlights the potential of hypermedia to enable 'discovery-based learning' and provides a history of the development of this educational philosophy from Socrates through Rousseau, Dewey and others to Bruner and the present day. This potential has been noted by others; Schulmeister on HyperCard,

> *HyperCard and its navigational metaphor of browsing (sic) followed quite a different paradigm, one of 'discovery learning', a concept that has deep roots in Jean Piaget's genetic epistemology and a term that was coined and popularised by ...Jerome S. Bruner.*
>
> (Schulmeister. R. 1994 p.15)

He further describes HyperCard as *'a milestone in the history of computing (which) marked a shift in paradigm in educational software'*.

This paradigm shift has been dramatic. Hypermedia, and the availability of the

technology to support it, enabled a rapid swing away from the various computerised

manifestations of Skinnerian 'programmed leaning' and their associated behaviourist,

reductionist teaching methods into the brave new world of cognitive learning theories

and constructivism. However, in response to the demands of extreme constructivism,

Reushle provides insight for the need to temper this radical shift,

*...in an educational program, knowledge needs to be prespecified and
represented in some form of knowledge base.*
(Reushle. S. E. 1995 p. 148)

The prespecification of the knowledge base, and the interdependent relationship

between it and action and reflection in stimulating initial and new responses to a task,

has been a central theme in the task considerations. Furthermore, the task has been

shown to have a vital role in overcoming the problems associated with the effective

authoring of hypermedia documents. The most pressing issues highlighted by

pedagogical considerations in relation to the intended courseware are those of the

knowledge domain structure and user or system control, in supporting the effective use

of this prespecified knowledge base in the particular context in which this present

research is set. In addressing these issues it is useful to consider a continuum of

approaches which might then be used to inform practice in the development of the

courseware. Such a continuum might be polarised by pedagogical approaches thus,

Behaviourist ←————————→ Constructivist

Fig. 10

At the behaviourist pole coursware would be typified by programmed learning

approaches that are structured by the Skinnerian assertion that,

> *...complex behaviour can indeed be reduced to sequences of smaller*
> *elements, and that machines could be designed to present these to the*
> *learner, invite a response, and reward success by moving the learner to the*
> *next element in the sequence.*
>
> (Brown. G. 1995 p. 17)

Hence, control and structure are entirely with the system, and by association with the

selection of this system, the teacher.

At the constructivist pole courseware would be typified by hypermedia approaches that

are structured via the referential linking of knowledge. Smeaton describes this approach

as a *'purist's hypertext'* (Smeaton. A. F. 1991 p. 173). In its purest, and most theoretical,

form the control is entirely with the user or learner.

Completing the continuum requires extrapolation inwards from the poles via the dual

themes of structure and control. On the theme of structure Smeaton provides further

insight by categorising hypertext structures:

(a) Network hypertext organisation; (b) Strict hierarchical hypertext organisation; (c)

Combination of hierarchical and network hypertext organisation

Fig. 11 (Smeaton. A. F. 1991 p. 173 - 174)

It is evident from these classifications that there is a gradual transition in structural

coherence from the amorphous network organisation to the ordered hierarchical

organisation and, in further extrapolating this transition, further coherence could be

applied to the network structure by removal of divergent branches; the end point of the

extrapolation occurring at the linear sequence of programmed learning. Moreover, it

emerges that a significant amount of control is applied by the level of coherence in the

structure. To explain this phenomenon of control applied by structural coherence it is

useful to relate the nodes and links to space and movement.

Consider first the simple linear structure of linked nodes where the starting point is at

the top and the end point at the bottom. The user exists in a linear space and can only

move up or down the line. This represents a highly controlled situation and the user will

always reach the same end point. There is no scope for the association of ideas and

concepts other than those that are imposed by the structure.

As the structure becomes less coherent, by the addition of branches in a hierarchical

organisation, the user now encounters an increasing number of optional directions. Their

progress is restricted to movement up or down the hierarchy and, although increased in

number, the end points are still predetermined. There is more scope for the association

of ideas and concepts as the number of potential end-points has increased but much

control is still applied by the structure.

Cross-linking the major nodes in the hierarchy further reduces the coherence of the

structure and the user is now afforded the ability to not only move up and down the

hierarchy but to 'teleport' across large sections of it. As more 'teleportation' links are

made available the linking structure moves away from the hierarchical and towards the referential. There is increased scope for the association of ideas and concepts, but, as this process of change from hierarchical to referential linking increases, less control is applied by the structure and the end-points become less apparent.

In the purist's network structure all hierarchical links become referential links. The user now has no notion of space and structure as their movement around the network is all achieved via 'teleportation', which results in the removal of hierarchy and the emergence of parity of nodes. The only control exerted by the system in this 'hyperSpace' is in the number of nodes and links made available and it is left to the user to impose order on the structure and to identify end-points for themselves.

The emergent continuum displays an interdependent link between the extent of the control that is implicit in the structure and the coherence, or linearity, of the structure; where the coherence of the structure is reduced by the addition of branches to the hierarchy and the referential, cross-linking of nodes. Simply stated - as the structure becomes more 'fluid' the implicit control is reduced and the educational approaches 'morph' from the behaviourist to the constructivist.
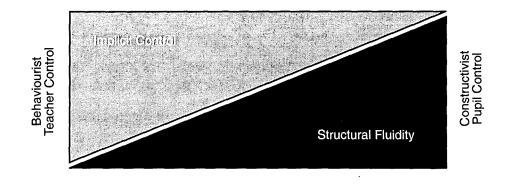
Fig. 12 - Continuum of approaches for courseware design.

Having formulated this continuum to inform practice in the development of the

courseware the issue of how it might be applied emerges. There are distinct similarities

between this continuum of approaches and the previously described teaching continua,

particularly that of Patterson (page 22), which might lead to the notion that the

successful design of the courseware might simply be reliant upon the parallel

application of this continuum of approaches, or its integration, with the teaching

continuum. However, such an application would rely upon the assumption that all

approaches contained within the continuum are valid and effective. However, the

literature highlights problems with all of these approaches.

At the far right of the continuum problems manifest themselves as users getting lost

within the structure. Thimbleby on user problems with hypermedia,

> *In a conventional document, even one that is badly designed, the reader can
> have a strategy for obtaining information, indeed, even for deciding whether
> the desired information is even available. For example, it is possible to 'flip'
> through a book and get a statistically good impression of its contents. The
> case with hypermedia is very different. There is no algorithmic way a user
> can determine what is in a document, nor whether what they seek is likely to
> be there anyway. Unless the user knows and understands the document's
> structure and the document actually conforms to the appearance, the user
> will get lost.*

(Thimbleby 1995b)

Some of these problems might be overcome by the prespecification of the knowledge

base that the hypermedia contains, so ensuring the relevance of the material to the user.

However, the problem of 'getting lost' remains.

Smeaton on the 'purist's hypertext',

> *... such a structure can present problems when navigated by users who can easily become lost as the topology of the hypertext is monotonous and lacks guiding features*
>
> (Smeaton. A. F. 1991 p. 173)

These views are supported by Hutchings et. al. in partial answer to their own question,

'What makes for educationally effective hypermedia ?' ,

> *Creating an amorphous network of nodes and links through which the learner is left to sink or swim may be even less effective than a straight-jacket of programmed learning... an associated problem is one of 'going round in circles', whereby users do not identify and ignore links to nodes that have recently been viewed... There is evidence of other problems associated with learning from the more basic forms of hypermedia: getting lost, 'failing to see the wood for the trees', failing to find material, unmotivated rambling, and problems with the interface.*
>
> (Hutchings. G. A. et.al. 1992 p. 171 - 172)

The view of programmed learning as a 'straight-jacket' is not uncommon. Jacobs

provides the following objections,

> *The first is that programmed instruction inherently depends on an acceptance that the teacher can see further and more clearly than the pupil, and consequently that each step presented is the best one to take in order to maximise progress, whereas the predetermining of a path goes against the grain of the intuitive and disordered way in which people learn effectively. The second objection is that in many situations learners balk at a programmed approach, and veer off whenever possible into trial and error.*
>
> (Jacobs. G. 1992 p. 118)

To overcome the problems of getting lost and avoiding the 'straight-jacket' of programmed learning the appeal of a hierarchical organisation of the knowledge base emerges. Smeaton recognises this appeal in terms of the amenability of this approach to the conversion of conventional texts into hypertexts and in the support of navigation. However, he qualifies these views,

> *A hierarchical organisation of a hypertext provides convenient navigation for users who can use the structure to navigate, thus freeing them to concentrate more on what is being presented instead of worrying about where to go next. The disadvantage of a hypertext system constructed as a hierarchy is that it could be viewed as a an implementation of a conventional book using the computer, which allows users to follow cross-references quite rapidly. The current generation of hypertext systems would appear less effective than books for retrieving information when a user wants to find specific information.*
>
> (Smeaton. A. F. 1991 p. 173)

The existence of hypermedia, and its immediate predecessor computerised programmed learning, is dependent upon the technology used to support it. Jacobs (Jacobs. G. 1992) recognises the 'continuing synergy' of the relationship between education and technology with neither being fully in control of developments. It should not be surprising that when given a 'first generation' machine equipped with programming languages such as BASIC that the structures applied by that language, e.g. procedures called from IF...THEN... routines, should lead developers into utilising linear programmed learning approaches and to generate courseware based upon simulations and question and answer interactions. Even if dissatisfied with this approach developers will have great difficulty in shifting paradigm unless the technology changes. The advent of CD-ROMs, with their capacity to store large amounts of information in a range of media, which is accessed via linking and path-following interactions, stimulates a natural jump into constructive approaches. However, CD-ROMs can have a

detrimental effect upon the effective educational use of hypermedia and can also suffer

from the problems regarding information retrieval highlighted by Smeaton.

Thimbleby on CD-ROMs,

> *CD technology makes the issues worse. CDs are not only badly structured,*
> *but they have no memory. If a user is learning the contents of a CD, a day*
> *later they cannot continue. There is no one-dimensional notion of position:*
> *a user cannot come back and 'continue'... Having used the document, it is*
> *not possible to see just 'the rest' of the document. The document is always*
> *the same, and as it is used, the reader becomes increasingly frustrated that*
> *new material is harder and harder to find amongst all the already*
> *encountered material.*

(Thimbleby 1995b)

Although problematic these individual approaches can also be seen to have their own

particular advantages when used within an appropriate context. Reushle summarises

these views,

> *Traditional methods of instruction are often based on behaviouristic*
> *theories which are indeed adequate for acquiring procedural and*
> *psychomotor skills. However, when tasks involve problem solving, large*
> *amounts of knowledge or high workload requirements, designers tend to rely*
> *more on cognitive-based theories of learning and instruction.*

(Reushle. S. E. 1995 p. 147)

In all manifestations of hypermedia systems user control is simply an illusion. Pure

hypermedia is as much of a theoretical construct as Bush's Memex system, as it is

impossible to achieve unless the links are generated in an entirely dispassionate yet

referential manner, the information provision is entirely free from context and the

number of links and the extent of the knowledge domain is infinite. Design and

Technology is a context driven discipline so pure hypermedia, or the real-world illusion of pure hypermedia, derived from complex, organic, expanding networks, is burdened with difficulties from the outset. Moreover, the mastery of procedural and psychomotor skills, achievable with linear, programmed approaches, are a vital component of Design and Technology but do not in themselves lead towards Design and Technology capability.

Text books are a static medium and, necessarily, normally generic. They rarely provide information in context and when they do the only way to change the context is to rewrite the text. It is the teacher who provides the context by the framing of the project brief. The earlier premise of the teachers role in 'hyperising' texts coupled with the inherent difficulties of context free pure hypertext, hierarchical networks and linear programmed approaches further highlights the issue, that '... *more explicit direction and control, to restrict the learner to realistic goals and to a sensible part of the knowledge domain, needs to be judiciously mixed with freedom of action.*' (Hutchings. G. A. et.al. 1992 p. 173)

Hence, a delicate balancing act is required. Too little control afforded to the pupils, or a static level of control that does not take account of pupil progression is likely to lead to a lack of productive engagement with the courseware. Reushle cites the positive effects of learner control, i.e. allowing, '...*students to tailor their instructional experience to suit personal needs and interests*' , as '...*Improved attitudes, motivation, achievement and decreased anxiety...*' (Reushle. S. E. 1995 p. 149). However, Viau and Larivée qualify this view by stating that, '...*The weaker a learners prior knowledge, the less benefit is derived from learner control.*' (Viau. R. & Larivée. J. 1993 p.11)

What emerges is the need for the courseware to support and stimulate the traversal of the hierarchy of tasks and, in so doing, to provide an effective task entry point that enables the investigation of the generalised context and the completion of particularised tasks. Such courseware would draw from the whole spectrum of approaches and be able to switch effectively between them in a context sensitive, goal oriented situation in the same way that the pupils will be required to frequently switch their focus of activities from generalised contexts to particularised tasks. Control, a central issue in the pedagogical discussion needs, therefore, to be manifested in a variety of forms and to be judiciously applied. Furthermore, control in hypermedia networks is principally afforded by the fluidity of the structure and, hence, the courseware must have a dynamic structure that can support the variety of pedagogical approaches demanded by the subject of Design and Technology.

However, the pitfalls of each approach are well documented and even if the system were capable of switching between them as necessary it may still suffer from their individual inherent faults. In the task considerations the interrelationship between action, reflection and consultation with the knowledge base has been discussed and the role of the teacher in hyperising the texts to support applied pedagogy identified. Cornail-Engel provides further insight,

> *The act of teaching and learning cannot, of course, be carried out without using certain aids, but the raison d'être for these aids lies in the learning project which they support, and in the act of teaching and learning with which they are integrated. Here the teachers are in the forefront. They are the ones who most frequently initiate the activities which students carry out in the classroom or at home. When they are planning and preparing these activities, they base their work on what they know of pedagogical project design, and how they themselves introduce these activities.*

(Cornail-Engel. I. 1994 p. 251)

In the course of a typical project, information provided by a teacher, and the interaction between teacher and pupil, will develop from a general introduction to the specific needs of an individual. If the courseware is to be effective in supporting and developing procedural autonomy in pupils and it is to avoid the lack of productive engagement brought about by inappropriate levels of control then it must also be capable of responding effectively to the individual needs of pupils in a similar way to that of the teacher. Such a system would not only need to vary in structure as described above but would also need some other form of control that can tailor the courseware for an individual user based upon their previous use of it and their future needs. Such 'tailoring' might manifest itself in the information content and structure made available and the dynamic communication of what has been completed and what is left to complete. In essence the courseware would become matched not only to the set project but also to the pupil as an individual and in responding to the needs of the individual could be seen to be 'intelligent'.

The notion of 'intelligent hypermedia' is established in the literature. As a general concept intelligent hypermedia draws from techniques established in artificial intelligence, principally those of knowledge-based, expert systems. Woodhead in relating knowledge-based, expert systems to intelligent hypermedia systems, describes the manifestation of this 'intelligence' in an expert system as, '...*the onus of decision-making, in a dynamic context, is with the software rather than the user...*' and in an intelligent hypermedia system as, '...*context sensitive guidance by the system, as opposed to undirected navigation or browsing by the user.*'

(Woodhead. N. 1990 p. 36)

This is an important distinction between the two types of system when relating their use

to the context for this current research. A user of an expert system is able to question the

knowledge base of the system, which will then respond with an answer or

recommendation. The inappropriateness of this level of decision control being retained

by the system in a comparable context is discussed by Briggs et.al. in the description of

a hypertext based education system for pharmacists. They see the use of the expert

system to provide explicit information as to the nature of treatment for a specific set of

symptoms being of limited use to a pharmacist who needs,

> *...to be aware of the complex relationships between similar sets of symptoms and similar sets of products and drugs, and, in recommending a product, must feel secure both in their selection of one treatment and rejection of others. A straightforward expert systems approach supports the correct selection in a particular case but is weak in supporting the more general knowledge required to reject other treatments.*

(Briggs. J. et.al. 1993 p. 105)

In making the above analogous to the courseware, the pupils could simply select from a

range of input and output devices and the computer would respond with circuit

diagrams, printed circuit board layouts, component layouts etc. This leaves no scope for

the pupil to make decisions further than the initial concept and, more importantly, leaves

no opportunity for them to investigate the consequences or appropriateness of these

decisions. Furthermore, learning within this context is centred within investigating

available options, making selections and establishing their appropriateness for the

intended application context. This level of decision making cannot be supported by the

expert system but is better supported by intelligent hypermedia.

In the system described by Briggs. et. al. the 'intelligence' is provided by the automatic

generation of links by the system after the initial query is posed. This guides the user

into the most appropriate areas of the knowledge domain. In considering the task that

the courseware will be designed to support, there are potentially eighteen different

circuit configurations (6 possible inputs, 3 possible outputs) that the pupil can choose

from. This system of automatically generated links appears to be particularly applicable

in this context, whereby the pupil poses the query by selecting input and output devices

to be used and the system directs them to the appropriate areas of the knowledge

domain. Although the system contains information on the total knowledge domain,

individual users will have a personalised representation of it that dynamically changes

as a result of the decisions that they investigate and subsequently take. For the system to

operate in this way it must have some notion of who is using it and a memory of what

they have previously done. This facility is referred to as a 'user model'.

Hendly. et.al. in discussing the generation of hypermedia from knowledge domains say

that,

> *The most powerful way to do this would be to provide an intelligent system*
> *which dynamically generated the interaction with the user on the basis of a*
> *dynamic user model...*
> (Hendley. R. J. et.al. 1993 p. 128)

although they discount this approach as overly ambitious for their intended aims. It

could be argued that, in the knowledge domain that is encompassed by the courseware,

the user model could tend to be more stereotypical than truly dynamic. This concern has

to be offset against the practicalities of authoring the hypermedia where the size of the

space, i.e. the number of nodes within it and the complexity of the automatically

generated linking structure, will commensurately increase as the user model increases in levels of accuracy and individualism. The courseware has to facilitate the provision of information for eighteen different circuit options. The sequence of information provision would not necessarily be defined. So in considering a drastically simplified structure where only information about the inputs, processes and outputs were investigated, and no changes to initial decisions were taken, there are potentially six different sequences in which these could be 'read'.

This leads to the conclusion that there are up to one hundred and eight potential user models; stereotypical or not. Although complex this situation remains manageable with relatively straightforward algorithms for generating the links as the information nodes remain unchanged. In a truly dynamic situation the user model would have influence over not only the linking structure, but over the information nodes themselves. The potential for 'combinatorial explosion' (Woodhead. N. 1990 p. 117) in a situation such as this is massive. However, the inclusion of 'dynamic' nodes at key points within the structure would remain manageable and would further increase the usability of the system by augmenting the personalised representation of the knowledge domains.

The role of the user model in the courseware would be to enable it to provide context sensitive information to individual pupils who use it in their task directed activities. It would provide a powerful tool in guiding the pupils to information that is appropriate to their individual needs and in dynamically reflecting the activities that they have undertaken and what there is left for them to complete. Such a system may have the ability to bridge the gap between the computer based, technology driven, polarised approaches of behaviourism and constructivism and in so doing to avoid their pitfalls and to combine their powers; an approach that is enthusiastically championed by Stanton,

Indeed a practical solution to the problems of CAL system design might be to involve a combination of the two: the hypermedia interface allows learners to explore and make their own links, whilst an AI tutor provides help where needed and could 'structure' the data behind the user for speed of reference. The tutor could limit the number of available choices if the learner becomes overwhelmed by the environment. The degree of control that learners have could be increased as their competence increases, with natural transition from machine to user occurring without the learner overtly realising it... At one extreme, training could be presented to the students in a passive manner, involving them in little more than page turning, whilst at the other the students could have full control over what they choose to see and are actively involved in creating something new out of what already exists. This is the futuristic ideal of hypertext.

(Stanton. N. A. 1994 p.280)

Stanton's view, given from the perspective of general CAL design, is mirrored by Smith who makes similar requests and predictions from the perspective of design and technlogy.

CAL has had a poor reputation schools, from the days when it was largely drill and test. Much more imaginative CAL programmes should be possible with CD-ROM or CD-I, since they could also link with an analysis package. At present, there does not appear to be appropriate CAL materials which schools can afford, even if they had enough computers to run the software on.

(Smith. J.S. 1994b p.4)

Pupils in D&T often work on their own projects requiring individual knowledge or skills to complete the design and manufacture of their products. Computer-based mutimedia learning systems should soon have a significant role in the teaching of D&T.

(Smith. J.S. 1994a p.11)

Hence, this current research project aims to take a 'sneak preview' at Stanton's futuristic ideal by developing intelligent hypermedia courseware that can resolve the conflicting and supporting elements of its three principal design criteria, in learning situations that are structured by task-driven, goal-oriented concerns. It then seeks to understand how the resultant courseware interacts with the learning situations that it was designed to support. Solving this problem requires resolution of the uncertainty presented by the problem. By defining the problem parameters in this section the development of a solution, and a method to investigate its efficacy, can begin.

References:

Briggs. J. et.al. (1993) - Using Rules to Guide Learners Through Hypertext - Computers and Education:Pergamon Press:UK - vol.20 no.1

Brown. G. (1995) What is involved in Learning? - In **Desforges. C.** An Introduction to Teaching: Psychological Perspectives - Blackwell: Oxford

Cates. W. M. (1992) - Fifteen Principles for Designing More Effective Instructional Hypermedia/Multimedia Products - Educational Technology: December Edition

Cornail-Engel. I. (1994) - The School Textbook - Can We Now Throw it Away? - Educational Media International - vol.31 no. 4

Coupland. D. (1995) - Microserfs -Flamingo: London

DATA (1994) - Research Paper Number Two: A Survey of the Qualifications and Training Needs of Design and Technology Teachers in Secondary Schools - DATA:Wellesbourne

DES (1988) - National Curriculum Design and Technology Working Group: Interim Report - HMSO

DFE (1995) - Design and Technology in the National Curriculum - HMSO

Doherty. P. et.al. (1994) - In: **Banks. F.** Teaching Technology - Routledge: London

Eggleston. J. (1992) - Teaching Design and Technology - Open University Press:Buckingham

Hendley. R. J. et.al. (1993) - Hypermedia Generation from Domain Representaions - Computers and Education:Pergamon Press:UK - vol.20 no.1

Hutchings. G. A. et.al. (1992) - Authoring and Evaluation of Hypermedia for Education - Computers and Education:Pergamon Press:UK - vol.18 no. 1

Jacobs. G. (1992) - Hypermedia and discovery based learning: a historical perspective - British Journal of Educational Technology - vol.23 no. 2

Kimbell. R. (1991) - The Assessment of Performance in Design and Technology: The Final Report of the APU Design and Technology Project 1985-1991 - Schools Examination and Assessment Council: HMSO

Kimbell. R. (1994a) - Tasks in Technology: An Analysis of Their Purposes and Effects - International Journal of Technology and Design Education - Kluwer Academic Publishers: Netherlands - no. 4

Kimbell. R. (1994b) - Understanding Technological Approaches: The Final Report of Research Activities and Results, ESRC

Kimbell. R., et. al. (1996) - Understanding Practice in Design and Technology - Open University Press: Buckingham

McKnight.C., et. al (1989) : In **Hutchings. G. A.** Et.al. (1992) - Authoring and Evaluation of Hypermedia for Education - Computers and Education:Pergamon Press:UK

Patterson. J. (1994) - Teaching, Learning and Computers: A Bermuda Triangle? - The CTISS File No.17

Penfold. J. (1988) - Craft, Design and Technology: Past, Present and Future - Trentham Books: Stoke-on-Trent

Phillips. W. A. (1990) - Individual Author Prototyping: Desktop Development of Courseware - Computers and Education:Pergamon Press:UK - vol.14 no. 1

Reushle. S. E. (1995) - Design considerations and features in the development of hypermedia courseware. - Distance Education - vol.16 no. 1

Salkind. N. J. (1991) - The Big Mac Book: second edition - Que: Carmel U.S.A.

Schulmeister. R. (1994) - A Shift Of Paradigm - Syllabus: European edition - no.4

Shepard. T. (1990) - Education by Design - Stanley Thornes: London

Smeaton. A. F. (1991) - Using Hypertext for Computer Based Learning - Computers and Education:Pergamon Press:UK - vol.17 no.3

Smith. J. S. (1994a) - The use of IT in the Teaching and Learning of Design and Tecnology in Schools - Design and Technology Teaching - DATA: UK vol.26 no.3

Smith. J. S. (1994b) - Information Technology and Electronics - Electronics Education: IEE: UK - Autumn Edition

Thimbleby (1995a) - WWW Paper: Introduction - http://www.cs.mdx.ac.uk/esrc/ Author2.html

Thimbleby (1995b) - WWW Paper: Readers Problems - http://www.cs.mdx.ac.uk/esrc/ Author2.html

Tizard. J. & Martin. J. (1992) - Using Electronics to design a controlled environment - paper presented at 1992 IDATER Conference.

Viau. R. & Larivée. J. (1993) - Learning Tools with Hypertext: An Experiment.- Computers and Education:Pergamon Press:UK - vol.20 no.1

Woodhead. N. (1990) - Hypertext and Hypermedia: Theory and Applications - Dotesios Printers: Wiltshire

Chapter 2 - Defining the Problem and Proposing the Solution

Section 2 - Resolving the Uncertainty: A New Courseware Development Paradigm

> *Karla and I and a few Lisas tried to guess what the charades hand signal would be for "interactive multimedia product". A movie is where you turn a camera reel; a song is where you hold your hands to your lips; a book is two palms simulating open flaps. All we could come up with for multimedia was two hands going fidgety-fidgety in space. A definitive interface is certainly needed, if only to make charades an easier game to play five years from now.*

(Coupland. D. 1995 p.346)

Throughout section 1 of this chapter the discussion has focused upon the interrelationship between the task that is set and the pedagogy that is applied, within the situation that exists for the provision of the subject. These areas have been proposed as the three principal design criteria for the courseware. It has sought to establish how tasks might be formulated to enable the educational aims of the subject to be achieved and how courseware might be designed to reflect and support these pedagogical approaches. This analytical approach leads to a view of the hierarchies and interdependencies of the three principal design criteria. It is evident that the region of commonality in these relationships is significant as it is in this region that teaching and learning within the subject are situated and where effectively designed courseware must also lie.
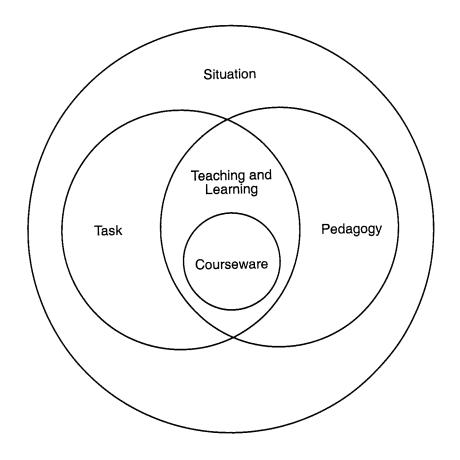
Fig.13 The relationship between the courseware and the three principal design criteria.

Courseware Design Specification

This model enables an outline design specification to be formulated in broad and practical terms with the evident hierarchy and interdependencies teased out into individual criteria thus:

1. The courseware should be deliverable by one or two modestly specified computers set within a design and technology workshop.

2. The courseware should be paced to run within a typical project time span (1 term - 12 weeks) for an average group size (approx, 20 pupils), within a typical lesson format (1 to 2 lessons per week for 1 to 1.5 hours each lesson).

3. The courseware must progress the pupils at an appropriate rate, enabling access to information and providing activities, at times, and in sequences, that are consistent with their individual needs.

4. The courseware must be flexible enough to allow for the revision of pupil decisions in the light of their own learning or changing project needs within the task frame.

5. The courseware must be sufficiently structured to support individual pupil activities, avoiding the associated problems of disorientation in hyperspaces, yet afford sufficient learner control to engender positive pupil engagement with the courseware.

6. The courseware must be compatible with a task of 'type C' (page 42) where the knowledge base supports action and reflection and the traversal of the hierarchy of tasks.

7. The courseware must be an attractive asset to teachers by providing opportunities that might lead to -

a) improved levels of pupil autonomy, motivation, work rate, success and feelings of empowerment;

b) a sufficient level of support for teachers in the release of control to pupils, enabling greater control over the teaching situation as a whole, more time to support pupils in their work, with the associated feelings of empowerment.

8. Ideally the development of the courseware should enable the formulation of generic approaches, methods and principles which can be utilised in further applications.

Developing the Continuum of Approaches for Courseware Design

In common with most design projects the specification is the foundation on which the subsequent development is built and also the criteria by which the success of that

development may be evaluated. The satisfaction of this specification is the key indicator

to the success of this project. It is evident from the specification and the discussion

undertaken in section 1 of this chapter that conventional approaches to hypermedia

generation, whether they tend towards the pure or hierarchical will have a limited

success at satisfying these criteria (points 1, 2, 3, 5, 6, 7a, 7b) and that traditional linear

approaches will suffer from a similar level of difficulty (points 3, 4, 5, 6, 7a, 7b). As

these criteria have been formulated from the interrelated areas of the situation, task and

pedagogy, it emerges that a hierarchy relating to the ability of the courseware design

approach to satisfy these three principal design criteria can be constructed, and that this

hierarchy is reversed at the poles of the previously formulated continuum of approaches

for courseware design.
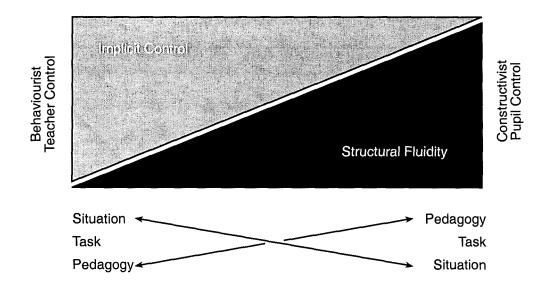
Fig. 14 A Continuum of Approaches for Courseware Design - Version 2

The reversal of this hierarchy, and the associated cross-over at the mid regions of the

continuum, perhaps highlights why hierarchical approaches are increasingly evident in

courseware design as they offer the best fit from a static structure but, more

significantly, demonstrates the centrality of the task in the courseware structure.

Satisfying all the constituents of the hierarchy requires traversal of the continuum and

the task will define how this traversal should be executed.

This task role might be further explained by revisiting Brown,

> *... to solve problems one usually needs to acquire some new information. In most real life situations there is far too much information for any one of us to assimilate. What we do is to select, and our selection strategies will depend to some extent on what we feel we need to know.*
>
> (Brown. G. 1995 p.22)

Brown places the onus of control on the problem solver to devise information selection

strategies, and to make the selections themselves from related information, to satisfy

their perceived information needs in the completion of a task. The role of the task, or

goal, will have a similar effect in structuring individuals interaction with hypermedia, in

that users will devise selection strategies (follow links) and select information (read

nodes) in a similar manner. A typical instance is given by Duchastel in describing how

students interact with an English Literature hypermedia collection,

> *Their efforts are somewhat constrained by a focus on fulfilling certain course requirements embodied in the exercises given them by the professor... Thus, the perspective of purpose of usage (how strong or weak the user's goals are as the interaction gets underway) is one of the main frameworks for examining hypermedia. It should be noted that we are dealing here with the learner's (user's) goal orientation, and not with the instructor's (system builder's).*
>
> (Duchastel. P. 1990 p.224-225)

As has already been discussed there are inherent problems in the use of hypermedia

especially if it is badly, or inappropriately, structured. Even if users are guided by a task

that is set, or the information retrieval goals that they have, the structure of the

hypermedia, the links between the nodes and the contents of the nodes, will affect the

effectiveness of users interactions with it.

As Stanton states,

> ... the learning process can be facilitated by providing an optimum
> environment within which learning can occur. A 'goodness of fit' is required
> between the learner and the learning environment in order to maximise the
> uptake of the material to be learnt.

(Stanton. N. A. 1994 p.284)

He continues,

> Bearing in mind the discussion of people using hypertext, it should be
> apparent that users tend to be very task specific in their activity. If they
> cannot perform the task they require, they will often return to the first page
> and try again. Such behaviour is both very inefficient, and very common.

(Stanton. N. A. 1994 p.290)

Smeaton cites a similar instance of backtracking and proposes a possible link between

revisiting and disorientation,

> When asked for specific information from the hypertext, users almost always
> use unstructured methods. In our environment users tended not to browse
> too far before backtracking, usually 3, 4 or 5 nodes. This could be because
> the users would have read enough on the current topic and wanted to move
> onto something else, or it could be attributed to disorientation caused by the
> poor support for navigation of the browser tool.

(Smeaton. A. 1991 p.178)

User disorientation and backtracking to reorientate suggest a lack of Stanton's

'goodness of fit' even when users are strongly guided by a task. It is significant that

Duchastel makes the distinction between the goal of the user and the goal of the system

builder, because if the information selection strategies of the user are based upon the

links that are available, then the forger of those links, the author, is participating in the

formulation of those selection strategies; that is unless the author can achieve pure

hypermedia, which as has been suggested in chapter 1 can never be more than a

theoretical construct. Also, that as the hypermedia tends more towards the pure end of

the spectrum the likelihood of the author achieving a 'goodness of fit' will become less

certain. Revisiting Thimbleby,

> *Users 'get lost in hyperspace' because authors don't make good hypertext*
> *documents; they don't make good documents because it is difficult to do so;*
> *and there are no powerful tools to help them control the complexity of the*
> *design problem. Without adequate management of the design process, the*
> *task fit of a given hypertext document is a matter of chance.*
>
> (Thimbleby. H. 1995a)

...'a matter of chance' if the links provided by the author do not enable a positive

interaction with the hypermedia in the completion of the task or satisfaction of the users

goals. Stanton recognises this author's role ,

> *In hypertext, links are determined by the authors' structuring of information.*
> *This inevitably means that the links will be arbitrary. In other words, there*
> *is no inherent reason why one piece of information should be linked to*
> *another.*
>
> (Stanton. N. A. 1994 p.290)

Stanton's arbitrary links are again a recognition of the task. The author links the

information in a way that they feel will best enable the intended task/s, yet an objective

observer might consider those links to be subjectively structured and, hence, the more

distantly situated the observer is from the task the more arbitrary the links appear. This

becomes almost a circular argument as a purely objective view of hypermedia would

encompass the notion of 'the referential linking of information'. The question of why

one area of information (node) refers (links) to another area of information is answered

by the semantic association that is made by the author between the two areas; and that

the semantic association will be derived from the likely task, or tasks, that the author is

attempting to enable. What emerges is that the semantics of the linking structure is a

further source of information that is layered over the existing information nodes by the

author.

In defining the extensiveness of a hypermedia system that circumscribes a topic,

Duchastel recognises this secondary layer of information provided by the links,

> *Extensiveness here refers to the sheer volume of information that is*
> *available to the user for the construction of knowledge. In hypermedia, it*
> *refers in particularly to the extent of the connections between nodes of*
> *information. These links must be considered themselves elements of*
> *information, for they are not only means of traversing a network, but*
> *embody as well the semantic relationships between nodes (even if these are*
> *generally non-explicit).*
>
> (Duchastel. P. 1990 p.225)

It is evident that these 'semantic relationships between nodes' are made by the author or

system builder. Of course as the hypermedia tends towards the pure end of the spectrum

the semantic association between the links becomes looser (elephant might lead to grey

or circus, as well as pachyderm or ivory). However, the links themselves still perform a

role in expressing the semantic association between nodes, but the onus of making that

association passes from the system builder to the system user. In explaining the

structure and navigation of their hypermedia system, Arents and Bogaerts refer to this

relationship between semantic associations and link traversal,

> *... links do not express meanings themselves, but express meaning through*
> *their navigation. It is not in the links themselves, but by navigating through*
> *the links that the meaning of the links becomes clear.*
>
> (Arents. H. and Bogaerts. W. 1991 p. 137)

The importance of semantic relationships to hypermedia organisation in overcoming the

problems associated with navigation are evident. In comparing semantic networks to

pure hypertext Stanton states that in semantic networks,

> *...information is organised meaningfully. This is in direct contrast to the*
> *organisation within current hypertext applications; if the information was*
> *organised meaningfully, then navigation would not be an issue.*
>
> (Stanton. N. A. 1994 p.290)

Some credence is lent to this assertion by Arents and Bogaerts who give the following

view,

> *We believe that without clear navigation semantics, knowledge of what the*
> *system contains and how that information is related to each other is too*
> *much dependent on the reader's familiarity with the system instead of on his*
> *understanding of the system's content. Navigation should therefore be*
> *considered as not simply consisting of links, but as the expression of the*
> *contents semantics.*
>
> (Arents. H. and Bogaerts. W. 1991 p. 137)

These 'navigation semantics' could be described as a narrative that is applied to the information nodes. A narrative produced by a system builder enables effective navigation and a good task fit to the hypermedia and a narrative produced by a system user exemplifies their personalised construction of knowledge from the information space. However, the user produced narrative will be constrained by the extent of the information nodes made available.

In subsequently reexamining the developed continuum of approaches for courseware design it becomes evident that a further layer of control (meta-control) is applied, which is layered over the general controlling influence exerted by the structural fluidity of the network. This meta-control enables overall levels of control to be applied that do not relate to the form of the network, but to the components of the network. At the behaviourist pole of the continuum the meta-control focusses upon the links that are made by the system builder. As the continuum is traversed more links, and hence nodes, are made available and are structured by the semantic associations that are made by the author, which have in turn been defined by the task that is to be enabled. As the constructivist pole of the continuum is approached, the focus of the meta-control can no longer be on the links as the onus of making semantic associations between the linked nodes passes from the system builder to the system user. The meta-control, therefore, now begins to focus upon the nodes that are made available rather than the links that join them.

Links ←————————— Metacontrol ——————————→ Nodes
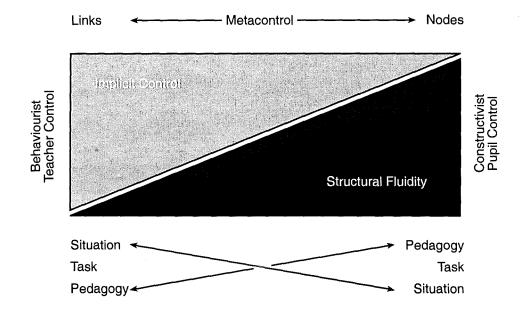
Fig. 15   A continuum of approaches for courseware design - version 3

The ability to apply this meta-control is significant as the satisfaction of the hierarchy,

derived from the three principal design criteria, requires traversal of the continuum of

approaches and a 'goodness of fit' is required if users are to be effective in completing

their tasks. The 'goodness of fit' will be characterised by the relevance of the nodes that

are made available and the applicability of the semantic links that are made between

them, which in turn are definable by a mechanism that is derived from the notion of

meta-control applied by the author or system builder.

The discussion so far has concentrated on establishing the role of the task in structuring

a system users interaction with the hypermedia and in the structuring of the hypermedia

itself by the system builder. What remains to be established is how the task can define

how the continuum of approaches is to be traversed. If the courseware is to be effective

then it must be responsive to the needs of the user and have these needs firmly

embedded within its structure and operation. Stanton interestingly cites ergonomics as a

valuable design consideration,

Ergonomics has emphasised the need for user centre design for many years. It proposes that information should be provided to people in the format which is most appropriate to their task in hand, and at a time which is most beneficial to them. The much cited phenomenon of getting lost in hypertext documents suggests that this principle is being violated in hypertext design.

(Stanton. N. A. 1994 p.288)

The principle is eminently sensible and relies upon establishing what information the user is likely to require, when they are likely to require it and then applying these conclusions to the information via a mechanism derived from the notion of meta-control; essentially deciding and controlling the content and sequencing of the courseware via the task. Courseware that is effectively designed to support the task will enable high levels of cognitive engagement with the courseware in completion of the task; an issue that is highlighted by Viau and Larivée,

...our chief conclusion from this preliminary study is the necessity to direct our research into the role that the learning environment must play in the learners' cognitive engagement in carrying out the task. The structure of the content and the learning tools must encourage the learners' use of cognitive and self regulated processes that are behind their cognitive engagement with a learning task.
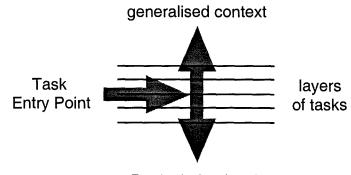
(Viau. R. and Larivée. J. 1993 p. 16)

Criterion number 6 in the design specification points to how this effective cognitive engagement might be enabled,

6. The courseware must be compatible with a task of 'type C' (page 42) where the knowledge base supports action and reflection and the traversal of the hierarchy of tasks.

In reexamining Kimbell's Hierarchy of tasks it is evident that there are striking

similarities between the nature of the activities that are undertaken across the range of

his hierarchy and the information structure proposed by the continuum of courseware

design approaches.

generalised context

Task
Entry Point

layers
of tasks

Particularised task

Fig. 16

Kimbell's hierarchy has 3 major components. At the poles are generalised contexts and

particularised tasks, where one metamorphoses into the other through the layers of

tasks. The task entry point defines the layer at which the pupil is introduced to the

project. It is evident that the activities typified by these terms require information

provision structures, and retrieval strategies, that map onto the poles of the continuum

of courseware approaches. The exploration of generalised contexts can best be served

via hypermedia like structures which lie towards the constructivist pole of the

continuum,where the narrative is constructed by the system user although regulated by

the meta-control which concentrates on nodes. Particularised tasks can best be served by

more linear approaches where the narrative is constructed by the system builder and the

meta-control is firmly applied by the links. The subject pedagogy will cause the task

entry point to tend towards the hierarchical network organisations in the mid regions of

the continuum where the narrative is shared between the system builder and the system

user. The system builder provides nodes and links them hierarchically via the semantic associations that they make between the information nodes. The system user follows links and reads nodes (takes routes) that are particular to their task, that is set within the task frame, that is circumscribed by the information space.

In order that these relationships can be represented diagrammatically we must take the liberty of rotating Kimbell's hierarchy of tasks by 90° and then align it with the continuum of courseware design approaches.
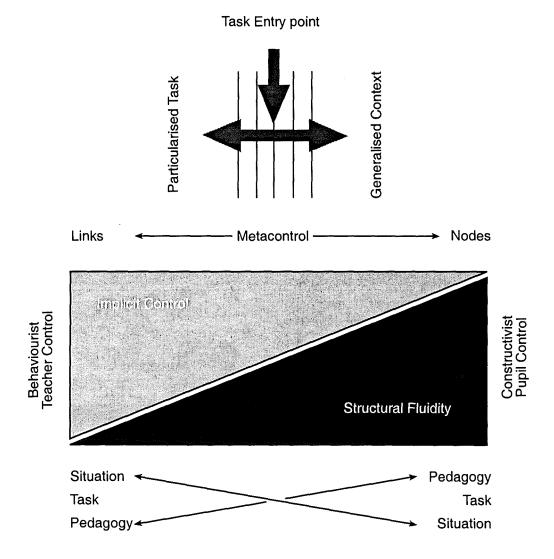
Fig. 17 A continuum of approaches for courseware design - version 4

Developing a Model for Courseware Interaction

From this courseware/task model a further model can now be teased out that represents

how a task can define how the continuum of approaches is to be traversed and,

moreover, that would represent users' interactions with the courseware in the

completion of the task. A task entry point is given and the system user enters a

hierarchically organised information space. The hierarchical organisation is essentially

used as a 'decision tree' where the organisation of the information defines the frame in

which the task has been set and aids the system user in selecting possible solutions to

the given task. A selection is made that appears to satisfy the task requirements, which

leads to the opportunity to investigate the appropriateness of the selection via a

hypermedia like structure. This hypermedia like structure enables the system user to

begin building their personalised construction of knowledge from the information space

and, hence, to confirm or reject their initial selections. Rejection leads back into the

'decision tree' facilitated by the hierarchical organisation and confirmation leads to a

particularised task. This task completion is facilitated by linearly structured,

instructional information, which leads towards the realisation of the chosen solution.
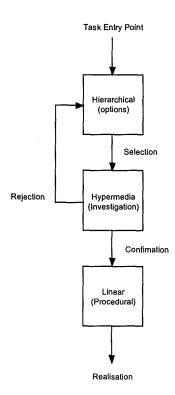
Fig. 18 Model for courseware interaction

As an underlying principle this model for interaction with the courseware is effective. It is formulated in response to the demands of the courseware/task model and, once the task is broken down into separate information nodes, it can provide the system builder with a methodology for link forging. However, upon further scrutiny it becomes apparent that additional development is needed to overcome two significant deficiencies:

1. How do you 'escape' from the hypermedia?

When the use of hypermedia is considered a system builder is constantly confronted by concerns relating to disorientation, getting lost and cognitive overhead (expending more effort in navigating than in learning). An essential outcome from the users interaction with the hypermedia is the confirmation or rejection of a chosen solution, which notionally requires navigation to the node that enables this decision to be made, at a time, and in a sequence, that can effectively enable a sound decision to be made by the user.

2. How is the courseware made user sensitive?

This is a simplistic model which could be satisfied by an albeit well designed, but essentially static structure. In this mode all of the information would necessarily always be available. Users would continually be confronted by options that did not relate to decisions that they had previously taken leading to potential disorientation and lack of productive engagement. Moreover, there is no apparent method by which the sequence of major task stages can be controlled by the system, e.g. the user might decide to enter a hypermedia domain relating to fault finding before the circuit has been constructed. Admittedly this may have some relevance for the user that is more distantly situated from the task, but it would not be an efficient, or necessarily coherent progression route. As a result it would fail to satisfy the situational, to some extent task and, hence, the pedagogical considerations within the principal design criteria.

Elliot et al provide insight into how these deficiencies might be satisfied,

> *Some form of narrative, story-line or guided discovery mechanism is needed in order to 'make sense' of a hypermedia corpus.*
> (Elliot et al., 1995 p.295)

The notion of a 'narrative' has a particular resonance as it has already been used in this discussion as a metaphorical reference to describe a system user's interactions with, and a system builder's structuring of, a hypermedia domain. In developing this notion of narrative into Elliot et al's 'guided discovery mechanism' what emerges is the need for a synthesis, or interaction, of narratives; the process of which is defined by the model of courseware interaction. This is essentially an interchange between the actions of the system user and the intentions of the system builder that are synthesised by the system to structure future interactions. It is this interaction and synthesis of narratives that form the user model proposed as a potential solution to satisfy the three principle design criteria in chapter 1 and the system's use of this model that forms the guided discovery mechanism or 'intelligence'.

A system that had this 'intelligence' embedded within it would overcome many of the previously highlighted difficulties, but 'escaping the hypermedia' would potentially remain. Much discussion has already taken place in order to construct a continuum of approaches to courseware design where the poles of that continuum are typified by linear and pure hypermedia approaches. However, the region subtended by these poles has only been described in terms of the 'fluidity' of the network structure and the effect upon the focus for meta-control. A greater degree of definition of the approaches that system builders can utilise within the continuum might lead to more appropriate, or accurate, specification of the 'hypermedia' section of the model for courseware interaction that is used to confirm or reject a choice.

In examining cognitive processing by users of hypermedia Duchastel makes a useful

observation,

> *There is yet no taxonomy of hypermedia styles, such as has evolved for*
> *instance in the world of computer assisted instruction (tutorial, drill and*
> *practice, simulation, etc.).*
> (Duchastel. P. 1990 p.222)

Duchastel makes this observation as hypermedia may be used to undertake a variety of

tasks, and , as has been discussed, control over the interactions can pass between system

user, system builder and system. It is evident that a 'taxonomy of hypermedia styles'

would enable more accurate specification of the 'hypermedia' section of the model for

courseware interaction. In formulating such a taxonomy it is reasonable to continue with

the spatial metaphor that is often applied to hypermedia.

In its purest sense hypermedia needs to be explored by a user, which gives one

classification in the taxonomy. This exploration can be subdivided into two further

activities. Users who have developed a familiarity with the hypermedia structure, or

who have clearly defined tasks or goals are said to navigate through the link structure to

a desired node. Conversely users who have little familiarity with the hypermedia

structure, or who have less clearly defined tasks or goals are said to browse through the

nodes and make serendipitous path experiments by following links. Browsing is the

interaction that stimulates the most tension between behaviourists (aimless wandering)

and constructivists (cognitive processing).

Taking a more detached (semantically looser) view of exploration would enable its

definition in terms of travelling into another country to learn about it, where the

travelling might involve the two activities of navigating and wandering. The explorer

will have things to establish by their travel but will discover other things simply by the

act of being there. However, there are other forms of purposeful movement or travel that

are different in nature to the activities undertaken by a fearless explorer at the

constructivist pole. Siviter and Brown use the term excursions in their description of a

possible 'hypercourseware' system and describe their use in overcoming problems

associated with disorientation,

> *Within any educational activity, e.g. a presentation, the structure is totally*
> *the responsibility of an author and can be as simple or as complex as*
> *desired. One approach is to keep the structure of an educational activity*
> *deliberately simple, typically a linear excursion through primitive activities*
> *with occasional sub-excursions, none of which depart significantly from the*
> *particular educational activity being pursued and none of which perform*
> *any radical navigational steps such as changing topic. Excursions are*
> *intended to feel like temporary journeys away from, and usually back to, the*
> *topic home ground.*

(Siviter. D. and Brown. K. 1992 p. 166)

So excursions have more structure than explorations and, by their definition, normally

end in the same place at which they began. Without wishing to overstretch the

metaphor, this new notion of excursions leads to other terms which describe purposeful

movement and how these movements interrelate. For example a traveller might make a

visit to a town, country or region and from that place could plan a series of excursions.

A sub-excursion might involve a tour around a historical building or village or

conversely a 'contained' exploration. The journey to a place could be completed in a

number of stages and would be usefully assisted by a map or other device with which a

traveller might orient themselves. The emergent taxonomy could evidently be expanded

considerably, although too many further stages of abstraction may cause the metaphor to become untenable. However, the classifications arrived at so far are potentially useful in enabling a more accurate specification of the 'hypermedia' section of the model for courseware interaction.

Exploration - To travel into another country to learn about it

Excursion - A short journey or ramble returning afterwards to the starting point

Tour - a guided journey trough a country, town or building visiting various places or things of interest.

Visit - To go to see a place for some purpose for a temporary stay

Stage - A stopping place on a route

Map - A representation of the earth's surface containing information about major landmarks and navigable routes

Orientation/reorientation (disorientation) - to get (lose) ones bearings or to become accustomed to (be confused by) a new situation

In reexamining the model for courseware interaction, in light of this formulation of a taxonomy of hypermedia styles, it becomes apparent that an excursion might overcome the problems associated with escaping the hypermedia; in that the essentially circular, or closed-loop, nature of the excursion, even those with sub-excursions, would naturally lead the system user back to the node at which confirmation or rejection of the chosen solution could be specified, at a time that is subsequent to the associated investigation. Moreover, the nature of the excursions made available would form the 'guided discovery mechanism', or intelligence, which is derived from the user model, that has been formulated by the synthesis of narratives, which are applied by the intentions of the system builder and maintained by the actions of the system user. Hence, an

individualised 'interface' to the courseware can be generated by the intelligence

(intelligence outcome) and the user's interactions could further inform the intelligence

(intelligence income). Furthermore, the dynamic structure enabled by the intelligence

outcome would enhance the potential for positive cognitive engagement with the

courseware by automatically ensuring a 'goodness of fit' between the set task and the

system user, and that 'goodness of fit' can be maintained through the intelligence

income. The process thus described has an essential similarity with the interaction of

teacher and pupil in the completion of a task of type C , which is supported by texts that

have been effectively hyperised by the teacher and, therefore, can be used to redefine

the model for courseware interaction and begin to develop it into a model for

courseware construction.

Task Entry Point
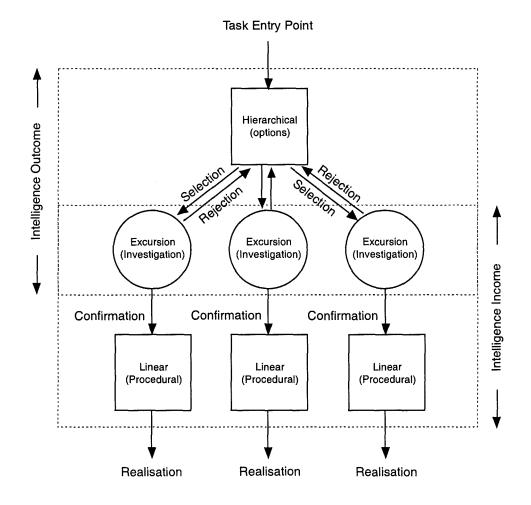
Fig. 19 A developed model for courseware interaction

This developing model for courseware construction now has the concept of the excursion, taken from the taxonomy of hypermedia styles, firmly embedded in the courseware structure, which is utilised to overcome the problems associated with escaping from the hypermedia. It also begins to describe how the intelligence outcome might be manifested and where the intelligence income might be sought. It is significant to note that the excursion becomes the area of narrative interchange between the system builder, system user and system.

Developing the 'Cognition Cluster'

The remaining area to be resolved is in using this model as a basis to construct courseware for tasks of a variety of complexities. It is evident that single stage tasks can be adequately facilitated by courseware based on this model. However, the potential for losing the 'goodness of fit', and associated pay off regarding levels of cognitive engagement, achieved via the application of the intelligence would increase with multiple stage tasks; and that as the number of task stages increases this detrimental effect would be increased commensurately. This conjecture is based upon the observation that there is no mechanism whereby the intelligence can manifestly sequence the stages of a task and, therefore, the model must be developed to encompass this requirement.

If this model can be used as a basis to construct courseware that can facilitate single stage tasks then facilitation of multiple stage tasks could be achieved by the iteration of the model, where the number of iterations would correspond to the number of task stages, and by developing a mechanism whereby the intelligence can sequence the stages and enable transfer from one stage to the next in a pedagogically coherent

manner that satisfies the authors intentions and with a goal oriented emphasis that

satisfies the users needs. Furthermore, the hierarchical network at which the task entry

point is situated can now be collapsed to a single level, as this is the node at which the

user interface is dynamically constructed by the intelligent application of the user

model. The collapse of this network to a node has further significance in that it now

exhibits the potential to be used as the point of application for the intelligence to

sequence the stages and enable transfer between them. The closest parallel to this

concept is expressed by Stanton in describing the work of Stanton and Baber in

overcoming the commonly identified problems of navigation and disorientation in

hyperspaces.

> *... they suggest that nodes be made more sophisticated. Nodes ought to be defined in terms of specific properties. The properties will include defined links, such as relate to nodes containing similar information. This concept is obviously very similar to object oriented programming ... The properties of nodes will then be the links, and will exhibit such characteristics as inheritance, membership etc.*
>
> (Stanton. N. A. 1994 p.291)

They style these nodes as 'definable nodes' and it is evident from their comparisons of

this approach to object oriented programming that the notion of the definable node is

comparable to a class, where the instantiations of that class become nodes with

embedded behaviours or properties, which are exemplified by inheritance, membership

etc. What is proposed here is that the node at which the task entry point is made has a

similar capacity to be defined, but that this definition, and the associated node

behaviours, are structured by the intelligence outcome, which is subsequently

maintained and 'tuned' by the intelligence income, i.e. the intelligent application of the

user model. Moreover, that the definition of these nodes should include the cluster of

excursions and resultant activities that are accessed from it and the conditional criteria

that must be satisfied before transfer to the next stage is enabled. Hence, the node now

becomes a stage in the hypermedia 'journey' to which visits are made. Transfer from

one stage to the next is achieved by the completion of the task stage. It is proposed that

the stage node, the cluster of excursions and activities associated with that stage, and

also the conditional criteria that must be satisfied before transfer is enabled, be referred

to collectively as a 'cognition cluster' . Furthermore, the developed model for

courseware construction be defined as the sequential combination of cognition clusters

supported by system intelligence derived from a dynamic user model.
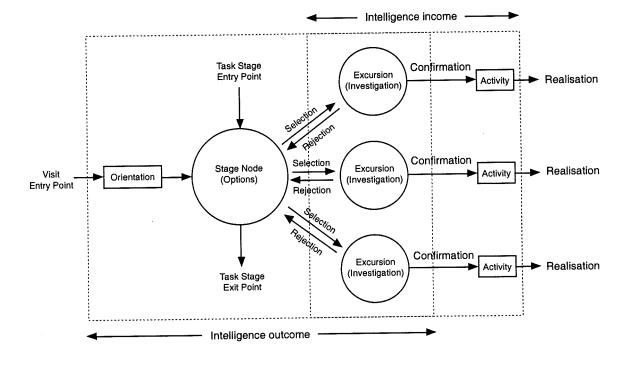
Fig. 20 A Cognition Cluster
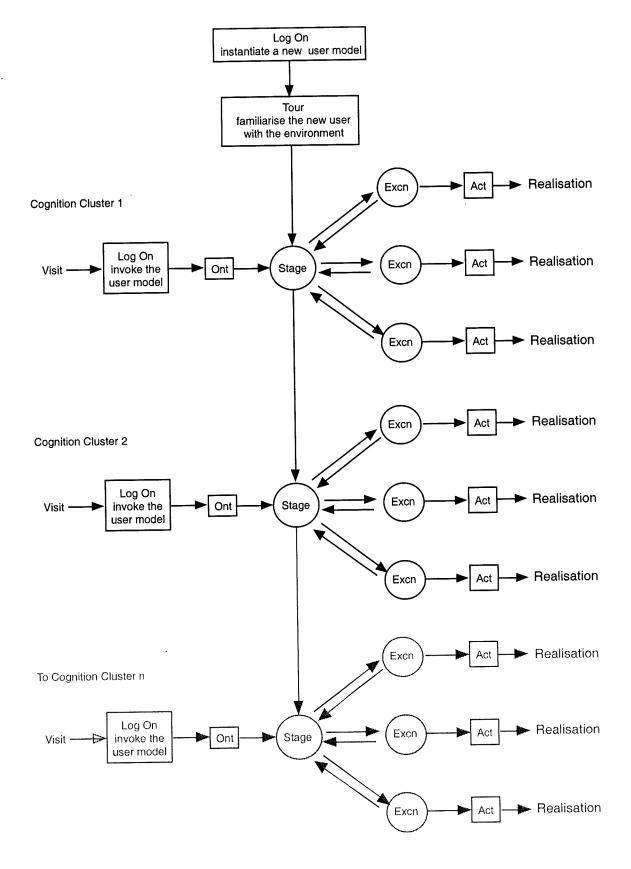
Figure 20 shows an example of a cognition cluster. It includes the stage entry and exit points and a visit entry point. Sufficient visits have to be made to the stage, and excursions and activities carried out, to satisfy the conditional criteria that enable exit from the stage. An optional orientation node is added that provides the facility to begin a visit with a reexamination of the last activity and/or decisions that have been made to date. An indication of where the intelligence outcome will be manifested and where the intelligence income will be sought is given.
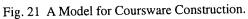
In the cognition cluster the system intelligence derived from the user model can be used to:

• Change the dynamic content of the stage nodes to construct the individualised 'user interface'.

• Control the excursions accessible from a stage.

• Structure the activity after exit from an excursion.

• Structure the orientation on subsequent visits.

• Enable or disable passage from one stage to the next or back to a previous one.

These are the essential components, relationships and control mechanisms of a cognition cluster. The node contents (static and dynamic), excursion count, manifestations of intelligence outcome and instances of intelligence income are dependent upon the task that is to be facilitated. A model for courseware construction, to facilitate the completion of multiple stage tasks, might now be constructed by sequentially combining, cognition clusters and supporting their operation by system intelligence derived from a dynamic user model. The structure will need to include the points at which a new user model is instantiated and subsequently invoked.

Fig. 21 A Model for Coursware Construction.

Courseware constructed using this model as the basis for development shows the

potential to satisfy the criteria listed in the design specification. Furthermore, it is

evident that the model is applicable to other situations with similar task driven, goal

oriented aims, that require decisions to be taken to enable the formulation of design

solutions to briefs set within a defined frame. However, if the broadest view is taken and

criterion number 8 is to be satisfied to the fullest extent, then the question must be asked

as to how such a model could incorporate nonproprietary, third-party hypermedia

corpus. This is necessary when the teaching continuum formulated in Chapter 1 (Page

21) is considered. As a task frame gets broader and deeper there would be an associated

need for the number of available excursions to increase commensurately and for the

onus of decision making to pass ever more to the system user. As generalised contexts

and particularised tasks become more distantly situated and encompass a greater breadth

of information for the construction of individual knowledge, the benefits afforded by

excursions may be overshadowed as they become overly restrictive. Furthermore, the

generation of propriety domains that can continue to participate in the narrative

interchange, that forms the basis of the construction of the user model, could explode

combinatorially into unmanageable proportions.

It is evident that if the growing number of third-party hypermedia based resources,

including CD ROM based material and the world wide web, could be effectively

integrated into this model for courseware construction, and the narrative interchange

could remain enabled, then the teaching continuum could be effectively facilitated

through to its upper reaches; areas in which the system user may not quite be at the level

of the fearless explorer at the extreme of the constructivist pole, but an individual who is

operating with high levels of procedural autonomy in relatively uncharted territory. If an

individual is to be released into such an area or domain, as a result of their interactions

with a cognition cluster, of which this domain forms a part, then they would need to be

provided with the necessary equipment in order that they could:

• retain a sense of goal orientation so that their interactions with the hypermedia domain remain driven by the task;

• retain a communication link with the intelligence embedded in the cognition cluster so that they might be given assistance or return before the sub-task has been completed;

• be given some form of translator so that the narrative that they construct as a result of their interactions with the third-party hypermedia domain can be translated into a form that will enable the interchange of narratives to be undertaken to develop the user model;

• be helped in deciding when the sub-task has been completed so that they might escape from the hypermedia and return to the stage node in the cognition cluster.

Searching for metaphors that describe this equipment may be entertaining, but there appears to be no single tool that would suffice. Solutions could undoubtedly take many forms, but a reasonable 'first shot' would appear to be a top-level floating windoid (small window) which serves as a conduit between the environment created by the cognition cluster and the differing environment created by the third-party hypermedia domain. The windoid would contain the necessary information and tools to satisfy the above criteria in a manner that requires the minimum cognitive overhead. Of course this proposal relies upon the third-party domains being selected by the system builder, but this can be seen simply as a further development of the manifestation of meta-control as the extremes of the continuum of courseware design approaches is neared.

An example of the windoid contents might be:

• a short statement provided by the system intelligence that describes the user's goal;

• a secondary statement that is updated by the system intelligence if this overall goal needs further division;

• a 'translator' and 'communicator' that can be used to send back the user's narrative to the system intelligence in a compatible manner, sequence and form such that the system intelligence can maintain the integrity of the cognition cluster as a whole. This should be enabled with the minimum of cognitive overhead. A series of multiple choice questions posed and updated by the system intelligence and answered via check boxes would serve this purpose, which could be further developed by the use of user text entry areas. This further development might require considerable system intelligence overhead to interpret the entered text unless the questions posed were relatively closed or if the text is simply to be stored and then re-presented for the user at a later time in the task and as a result of further interactions with the cognition cluster;

• a method by which the user can return to the stage node within the main body of the cognition cluster. This might be in the form of a button that enables manual return, a prompt, generated by the system intelligence, that informs the user that the sub-task/s to be carried out in this information space have been completed or an automatic return that is controlled by the system intelligence as a result of the satisfaction of conditional criteria formulated by the system intelligence.

These windoid adaptors would enable the third-party hypermedia 'square pegs' to be fitted into the cognition cluster excursion 'round holes' and enable courseware developed by the sequential combination of cognition clusters supported, by system intelligence derived from a dynamic user model, to facilitate teaching and learning at the upper reaches of the teaching continuum. Furthermore, such a combination would be both powerful and compelling as system builders could concentrate upon pedagogical matters yet still benefit from the 'bells and whistles' provided by hypermedia corpus developers. However, the scope of this study precludes their use so they remain as an intriguing and attractive future possibility, the relevance and potency of which becomes more conspicuously apparent as the recent development of key technologies stimulates the exponential expansion of the hypermedia 'universe' via CD-ROM and the WWW.

Designing the Courseware

Having formulated a model for the effective production of the courseware the remaining element of the process of this design project is to describe how this model might be applied to the chosen task. To undertake this process the following points must be addressed:

1. Break the overall task down into task stages that can be facilitated by a cognition cluster.

2. Begin 'growing' the cluster by:

a. specifying the nature of the excursions that will be made available from each stage node;

b. specifying the nature of orientation nodes that will be made available on repeat visits to a stage node;

c. formulating the criteria that will enable transfer from one stage to the next.

3. Build the courseware by sequencing the cognition clusters and decide whether the inter cluster links are mono or bidirectional.

4. Decide upon how the intelligence outcome might be manifested and where and what intelligence income will need to be sought.

The chosen task requires pupils to design and make an alarm system based upon a thyristor, which can be used in a specified context. This is the underlying concept to the project that the courseware will support. As a concept this is familiar to teachers and is evident within the National Curriculum, current practice at Key Stage 3, and the subject text-books. Breaking the electronics element of this project down into stages is relatively straightforward activity which is entirely comparable with the 'meat and drink' activities of a good lesson planning teacher. The most immediately apparent and straightforward outcome might be:

• Consider design brief and make some basic decisions about the application context (what is the alarm for? - bike, bag, bedroom, biscuit barrel?)

• Make choices of input and output system blocks to suit the system to the application context (How do I need it to work?)

• Find out how to realise the alarm on a component level (How do I make it work?):

i. realise the printed circuit board;

ii. find out about, select and mount the components on the printed circuit board;

iii. select and connect the appropriate power source; and

iv. set up and test the circuit

• Find out further information about the realised circuit, e.g. Fault finding (Why doesn't it work?), operation at a component level (How does it work?), etc.

However, the specific wording of the brief, the extent to which the project will be

completed (areas of associated practical activity) and the complementary teaching

inputs will not be stated as these will vary according to the situational considerations

and the preferences and previous experiences of teachers that are essentially beyond the

control of the courseware. This has to be recognised as pupils may be coming to the

courseware from slightly differing starting points with differing levels of decisions

taken about their project. The first cognition cluster must, therefore, invoke strategies

that cope with these differences to ensure a 'goodness of fit' and structure future

activities such that this situation may be maintained.

The first cluster is also key to the construction of the newly instantiated user model.

System users will take fundamental decisions about the operation of the input and

output stages of their system and, hence, their future interactions with the courseware,

and the construction of their personalised user interface, will be dependent upon these

decisions. Subsequent clusters should facilitate the realisation of these initial decisions

yet enable system users to modify their choices in the light of their own learning and

changing project needs. The emergent clusters would therefore be:

Cognition Cluster 1

The first cluster is entered after a user logs on to instantiate a new user model and

experiences a tour to familiarise them with the environment. The concepts that underlie

the notion of an alarm system must be gone through; this might serve as an explanation,

a reiteration or a reorientation for users, dependent upon their pre courseware use

experiences. Users need to be given the opportunity to investigate the available input

and output options via excursions and to make a choice based upon the application

context of their system. At this stage it is the applicability of these options to the

context, drawn from how they might function at a system level rather than at a

component level, that is the overriding emphasis for information provision. This process

of decision making will form the conditional criteria that enables exit to an activity and

progress to the next stage. Hence this cluster is essentially a single visit stage. Once the

decisions have been taken there is no need to revisit this stage unless the user wishes to

change their overall system design. The first activity is clearly focussed upon the

production of a printed circuit board on which the components that make up the system

stages might be mounted. Intelligence income has been gained by recording the user's

decisions and, hence, the user model is sufficiently detailed by this stage to provide the

user with an individualised printed circuit board, which would be the intelligence

outcome. However, it should be noted that all of the eighteen different circuits can be

constructed on the same circuit board. This is common practice at key stage 3 and is in

many ways a natural consequence, and a project management pay-off, from basing

teaching around a circuit configuration.

Fig. 22 Cognition Cluster One.
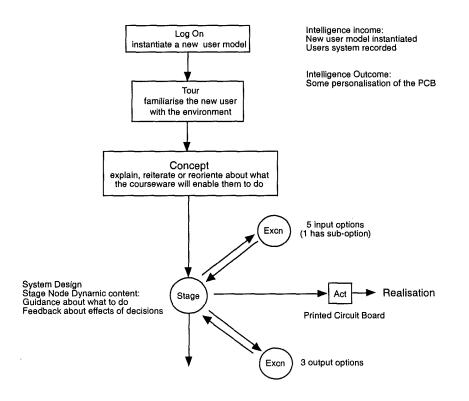
Cognition Cluster 2

The second cluster is entered after the user logs on. The user model is invoked and the intelligence outcome is an orientation activity based upon generic system concepts. Upon satisfactory completion the user enters the stage node. By reference to the user model the system intelligence can now embellish a generic system diagram with supplementary information that is specific to the user. It can also give feedback as to the general operational characteristics of the system. This would enable a natural decision point in the users interactions with the second cognition cluster, viz. does the user wish to continue with that system or do they wish to change it? The facility to change the system configuration necessitates a bidirectional link to the first cognition cluster. Following it back would involve the user in the excursions from the first cluster and subsequent confirmation of their choices would lead them back to the stage node of the second cognition cluster.

Excursions available within the cluster would now relate to the individual system blocks and their functioning and construction at a component level. The intelligence outcome would be manifested in the excursion links. Only the excursions that relate to previous choices recorded in the user model would be linked to the stage node. This begins to construct the individual 'user interface'. Each excursion block would naturally lead to an activity that involved the physical realisation of that stage. Intelligence income would include the recording of that stage completion in the user model.
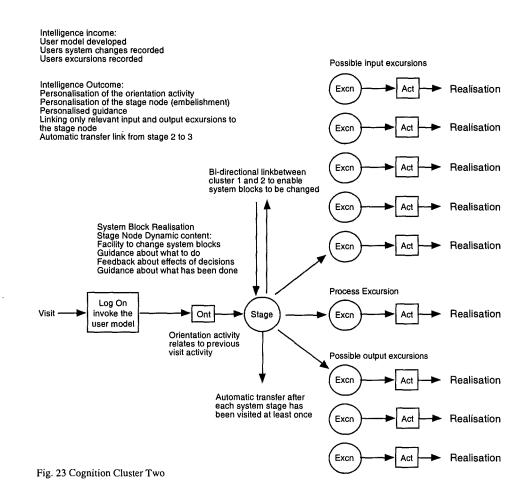
On subsequent visits to the cluster the user model is invoked and the first manifestation . of the system intelligence is the orientation activity that 'greets' the user. A record of the previous excursion and, hence, the most recent part of the circuit that has been constructed, is contained in the user model. The system intelligence can use this

information to ensure a direct match between the orientation activity and the previous

activity. On satisfactory completion the user can then again be provided with the

decision point. Excursions available from the cluster will still relate directly to the

choices made in cluster one but an intelligence outcome can also be to flag the stages

that have been completed. A user who chooses to follow an already completed stage

might be making a valid second visit to that excursion or they might be lost. The flag is

like a footprint which is a further manifestation of the intelligence outcome used to

construct an individualised user interface. As the excursions all lead to activities and a

log off point, the system intelligence could also ask the user to confirm that they wish to

see the material again, and in so doing provide a safety net for misdirected mouse

clicks, a focus for the users thoughts and a discouragement to purposeless wandering.

A major consideration relating to the manifestation of the intelligence outcome relates to

this second cluster. At some point the user must progress to the next stage and it is for

the system builder to decide how this might be achieved. From the very many possible

solutions there seems to be two that are the focus for considerations when the three

principle design criteria and the associated design specification are considered. Either a

link is established from the second cognition cluster to the third as an intelligence

outcome after at least one excursion has been completed for each system stage or the

user is automatically moved from the second cognition cluster to the third as an

intelligence outcome after at least one excursion has been completed for each system

stage. The distilled essence of the decision relates to striking a balance between the

situational and the pedagogical considerations, within courseware that advocates

supported exploration, but discourages aimless wandering. It is apparent that this issue

is bound up with the previously described notion of meta-control; how the influence of

system control is exerted upon, and experienced by, the system user. Automatically

moving the user from one stage to the next implies a lower level of procedural

autonomy than enabling a move when sufficient excursions have been completed and, by reasonable extrapolation, allowing users to move from one stage to the next via a permanent link implies yet higher levels of procedural autonomy. Might a system builder use these interrelated strategies to formulate a guiding continuum? If so then the automatic option appears to be initially more appropriate than the conditional link. However, this is obviously an issue that will have a significant effect upon the users interactions with the courseware and, hence, teachers perceptions of its efficacy when used within the unique instance of their own situation and to support their applied pedagogy.

Having selected the automatic option for enabling progress from this cluster to the next, the final intelligence outcome is the link established between this stage and the next after each stage has been visited at least once.

Intelligence income:
User model developed
Users system changes recorded
Users excursions recorded

Possible input excursions

Intelligence Outcome:
Personalisation of the orientation activity
Personalisation of the stage node (embelishment)
Personalised guidance
Linking only relevant input and output ecxursions to
the stage node
Automatic transfer link from stage 2 to 3

Bi-directional linkbetween
cluster 1 and 2 to enable
system blocks to be changed

System Block Realisation
Stage Node Dynamic content:
Facility to change system blocks
Guidance about what to do
Feedback about effects of decisions
Guidance about what has been done

Excn → Act → Realisation

Excn → Act → Realisation

Excn → Act → Realisation

Excn → Act → Realisation

Excn → Act → Realisation

Process Excursion

Visit → Log On invoke the user model → Ont → Stage → Excn → Act → Realisation

Orientation activity
relates to previous
visit activity

Possible output excursions

Automatic transfer after
each system stage has
been visited at least once

Excn → Act → Realisation

Excn → Act → Realisation

Excn → Act → Realisation

Fig. 23 Cognition Cluster Two

Cognition Cluster 3

The third cluster is entered after the user logs on. The user model is invoked and the intelligence outcome is an orientation activity based upon their last activity in cluster 2. Upon satisfactory completion the user enters the stage node. By reference to the user model it is possible to establish what the power supply requirements of the circuit will be and, hence, the next intelligence outcome will be to establish a link to the appropriate excursion that will enable realisation. It is evident that this cluster must also contain information about setting up and testing the circuit and there is an obvious sequence to these activities (connect the battery, switch the circuit on, test it). Hence, the next intelligence outcome will be to establish a link from the power supply excursion that is being followed to the appropriate setting up and testing activity. This cluster is, in a similar way to cluster one, a single visit stage so the final intelligence outcome is to establish a monodirectional link to cluster four after the activities have been completed.

Intelligence income:
User model developed
Users stage completion recorded

Intelligence Outcome:
Personalisation of the orientation activity
Personalisation of the stage node (embelishment)
Personalised guidance
Linking only relevant power supply excursion to
the stage node
Automatic link to relevant setting up and testing node
after excursions are completed
Automatic transfer link from stage 3 to 4

Setting up and testing

Battery excursions

6Volt

9Volt

Power Supply, Setting up and Testing
Stage Node Dynamic content:
Guidance about what to do
Guidance about what has been done

Visit   Log On
             invoke the   Ont   Stage
             user model

Orientation activity
relates to previous
visit activity

Switch excursion

Automatic transfer after
one comlete visit to the cluster

Fig. 24 Cognition Cluster Three

Cognition Cluster 4

The fourth cluster is entered after the user logs on. The user model is invoked and the intelligence outcome is an orientation activity based upon their last activity in cluster 3. This will be a multiple visit cluster and is the last stage in the task. It provides extension information, e.g. fault finding, circuit function, etc. Hence, the orientation activity is only encountered on the first visit to this cluster to 'round-up' the activities that relate directly to the completion of the task. Upon satisfactory completion of the orientation activity the user enters the stage node. The node has a number of links to the major areas for which it is an access point.

Fault Finding - The fault finding node can be embellished, as an intelligence outcome, by providing guidance information that relates to the realised circuit. Heuristic approaches that are linearly structured, are perhaps the most appropriate method by which the user can be guided through the process. In a circuit such as this the approaches will fall into one of two broad classifications that are essentially typified by the state of the output stage, e.g. the buzzer won't come on, the buzzer stays on all the time. Hence, two sets of eighteen excursions need to be potentially accessible from this point. It is important to note that the number of excursions that need to be made available within subsequent clusters in the courseware 'chain' appears to be suffering from combinatorial explosion. However, it should be recognised that much of the content of these excursions is either applicable to more than one excursion or derivable from the user model and generated by the system intelligence. So the intelligence outcome is not only the generation of the links but, in a many instances, the formation of elements of the excursion.

These considerations concerning the role of the system intelligence in overcoming some of the evident problems of combinatorial explosion apply equally to the other areas that would be appropriately contained within this cluster, e.g. circuit diagrams, circuit functioning etc. Fault finding is most germane to task completion and would, therefore, be an essential element of this courseware. The other areas are more optional and, hence, have not been specified.

Fig. 25 Cognition Cluster Four.

The four resultant clusters demonstrate an application of the courseware development paradigm previously described as the sequential combination of cognition clusters supported by system intelligence derived from a dynamic user model and, as such, completes the second phase in the development of the courseware. The 'futuristic ideal' tantalisingly propounded by Stanton (Stanton. N. A. 1994 p.280) can only be fully realised by the proposed windoid adaptors, which further enable and enhance the potential offered by this courseware development paradigm. Although the scope of this project precludes the development of these adaptors, the outcome still offers a previously unavailable courseware development paradigm that should enable effective, rather than simply impressive, courseware to be designed and a 'sneak preview' of this futuristic ideal to be seen. As Hutchings, et al, remind us,

> *Authors of effective hypermedia should appreciate that they are designing learning activities and mental experiences rather than screen displays or hypertext networks: process is foremost over product.*
>
> (Hutchings. G. et al. 1992 p.174)

The process has been defined the next stage must be to instantiate a prototype that exemplifies it.

References:

Arents. H. and Bogaerts. W. (1991) Towards an Architecture for Third-Order Hypermedia Systems - Hypermedia - vol.3 no.2

Brown. G. (1995) What is involved in Learning? - In **Desforges. C.** An Introduction to Teaching: Psychological Perspectives - Blackwell: Oxford

Coupland. D. (1995) Microserfs - Flamingo: London

Duchastel. P. (1990) Examining Cognitive Processing in Hypermedia Usage - Hypermedia - vol. 2 no.3

Elliot. G.J., et al. (1995) Supporting the Paradigm Shift: Hypermedia Construction with Concept Maps - The Easy Way Forward - Innovations in Education and Training International - vol.34 no.4

Hutchings. G. A., et.al. (1992) - Authoring and Evaluation of Hypermedia for Education - Computers and Education:Pergamon Press:UK - vol.18 no. 1

Siviter. D. & Brown. K. (1992) Hypercourseware - Computers and Education:Pergamon Press:UK - vol.18 no.1

Smeaton. A. F. (1991) - Using Hypertext for Computer Based Learning - Computers and Education:Pergamon Press:UK - vol.17 no.3

Stanton. N. A. (1994) Explorations into Hypertext: Spatial Metaphor Considered Harmful - Educational and Training Technology International - vol.31 no.4

Thimbleby (1995a) - WWW Paper: Introduction -http://www.cs.mdx.ac.uk/esrc/ Author2.html

Viau. R. & Larivée. J. (1993) - Learning Tools with Hypertext: An Experiment - Computers and Education:Pergamon Press:UK - vol.20 no.1

Chapter 3 -Operationalising the Research

Section 1 - Project Methodology

The methodological approach adopted and developed in operationalising this current research is driven and structured by evaluative concerns. This current research effort is situated within two major areas, viz:

• the design and production of the courseware

• the trialing and evaluation of the courseware

During the design and production phase the evaluative concerns are essentially formative. The review of aspects relating to the design of the courseware taken from the literature, and their subsequent analysis and synthesis, enables the formulation of a performance specification and the adoption or, as in this case, the innovation of a developmental paradigm. These are the cornerstones of the courseware building process and also provide the developer with the guiding criteria by which the formative evaluation might be applied. During this design and production phase the evaluative interplay between the developer and the guiding criteria is typically further augmented by feedback from user testing. However, in this formative phase the feedback from the

user is necessarily subordinate to the guiding criteria provided by the specification and the developmental paradigm. This subordinate relationship is necessary as the formative evaluation is directed towards the achievement of the overall objective of the design and production phase, which is typified by the successful instantiation of a prototype that exemplifies the principles established by the specification and the developmental paradigm. Hence, this phase of the research must draw from research and development methods.

During the trialing and evaluation phase the evaluative concerns are essentially summative, although subsequent iterations of the trial may provide formative opportunities. Typically, research and development methods encompass both formative and summative evaluation stages. However, it is unlikely they will be appropriate in evaluating the effectiveness of the courseware in a naturalistic setting as characterised by the context for this research. The evaluation of the effectiveness of the courseware in such a situation, demands a reversal of the subordinacy between the feedback from users and the guiding criteria provided by the specification and developmental paradigm. Hence, this phase of the research must follow more of an illuminative approach.

Knussen, et al describe the work of Parlett and Hamilton who originally developed this illuminative approach,

> *They coined the term illuminative evaluation to describe an approach which is essentially qualitative, where an understanding of the context or situation is crucial... The actual procedures and techniques employed vary according to the objectives of the evaluation... situational and personal variables will not be controlled.*

(Knussen. C., et al.1991 p.15)

They provide further insight into the essentially qualitative nature of this approach and, hence, its appropriateness for this phase of the research thus,

> *The more naturalistic the evaluation, the more weight is given to both personal and situational characteristics in the interpretation of findings. The illuminative model is appropriate when aiming to discover what happens to an innovation in practice.*
>
> (Knussen. C., et al.1991 p.15)
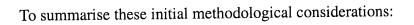
and in describing the work of Egan et al, they expand upon the operation of these situational characteristics,
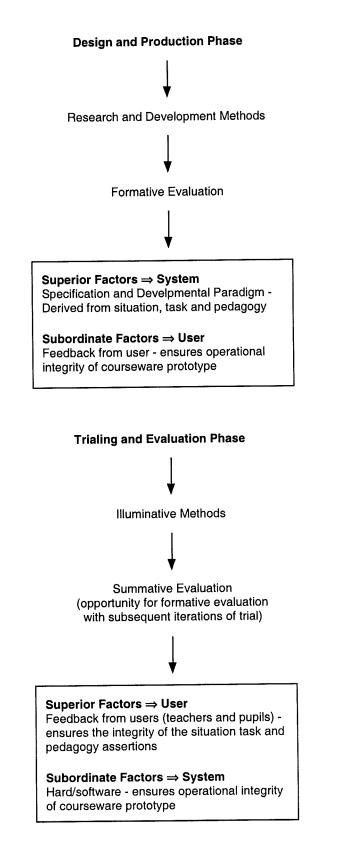
> *no (controlled) evaluation can predict how a given piece of software will actually be used within the classroom as this depends on the individual factors of the teaching approach adopted, the nature of the curriculum into which the software is introduced, the management strategies employed, and the needs and reactions of the users themselves.*
>
> (Knussen. C., et al.1991 p.21)

Hence, the three principal design criteria (situation, task and pedagogy) will necessarily affect the essential nature of the courseware and will also, by association, be the principal factors in how effective the courseware is in practice. A good match between the assertions made about these criteria and the real situation into which the courseware is introduced, should lead towards high levels of satisfaction with the courseware from teachers and pupils. This would in turn prove the validity of those assertions and their role in the development of the courseware.

To summarise these initial methodological considerations:

Design and Production Phase

↓

Research and Development Methods

↓

Formative Evaluation

↓

Superior Factors ⇒ System
Specification and Develpmental Paradigm -
Derived from situation, task and pedagogy

Subordinate Factors ⇒ User
Feedback from user - ensures operational
integrity of courseware prototype

Trialing and Evaluation Phase

↓

Illuminative Methods

↓

Summative Evaluation
(opportunity for formative evaluation
with subsequent iterations of trial)

↓

Superior Factors ⇒ User
Feedback from users (teachers and pupils) -
ensures the integrity of the situation task and
pedagogy assertions

Subordinate Factors ⇒ System
Hard/software - ensures operational integrity
of courseware prototype

Fig 26

The Design and Production Phase (Research and Development Methods)

From examination of the wide variety of extant software development models it is
evident that the development processes of these relatively new products borrow
methods from established product development cycles in the broadest context. It is the
essentially iterative nature of these processes that is the common binding theme.
Iteration is stimulated by developer and user testing, but, as has been discussed above,
this user testing is normally focussed upon ensuring the integrity of the system and its
capacity to enable the user to complete their task. By necessity, this testing is normally
focussed by time constraints and situational and personal variables have a low
significance as the testing is done in a controlled or quazi-naturalistic setting. However,
this level of control has to be accepted if forward progress is to be achieved within a
reasonable time scale and the end product is to exemplify the key characteristics desired
by the developer. It is unlikely that a radical new product, or paradigm shift, will be
solicited from user testing and feedback, but user testing and feedback is vital in
establishing the validity of the work of the developer. However, the production of
courseware is a complex and multidisciplinary activity and, hence, the role of the
'developer' is traditionally multifaceted and, hence, typically team based. It is the team
based nature of the developmental process that is often open to dichotomous difficulties
as a team will typically be constituted of one or more curriculum experts and one or
more computer experts.

In propounding an alternative approach Phillips highlights the three major
developmental phases where these dichotomous tensions are manifested. Firstly in the
initial conceptualisation and consultation phase,

...the curriculum and computer specialists balance the curricular needs with the computing constraints. The first breakdown in the team approach is likely to occur in this initial consultation phase. The computer specialists are not familiar with the curriculum issues and the curricular specialists are not aware of the computer's capabilities and limitations. The gap between their divergent points of view is widened by their technical language differences.

(Philips. W. A. 1990 P. 10)

secondly in the internal testing and review phase,

During the time required to complete the programming phase, the team members are exposed to new developments in other areas. Review of the preliminary results invariably generates new ideas and concepts - modifications to the original specification are almost always sought. Unfortunately, changes, while possible, are very costly at this stage of development. Significant changes necessitate reprogramming and renegotiation of the original specification...

(Philips. W. A. 1990 P. 10)
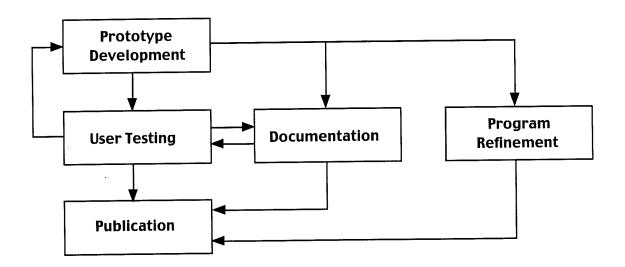
and finally in the user testing phase,

User testing signals the final, but essential, stage of development. At best, this phase exposes only minor flaws and necessitates only minor reprogramming to bring the system in line with curricular needs. At worst, modification is too expensive and the original project is abandoned.

(Philips. W. A. 1990 P. 10)

The alternative approach that Philips describes overcomes these difficulties by separating and sequencing the roles of the curriculum specialist and the computer specialist. By using one of a range of high level hypermedia development packages the curriculum specialist can concentrate upon the conceptualisation and development of a courseware prototype, where this phase is driven by pedagogical concerns derived from the developer's intentions and augmented by feedback from potential users. The prototype is easy to modify in light of both this user testing and of the developer's refinement or redirection of the initial concept. This prototyping phase can then be followed by extended user testing if the project time scale allows or can move into the next phase where the computer specialist can take the courseware concepts, operation and content and produce a functional product based upon sound computing practice. Philips styles this approach as, 'Individual Author Prototyping'. This approach appears to be particularly applicable to the context for this current research where a new paradigm is proposed for the development of courseware, i.e. the sequential combination of cognition clusters, supported by system intelligence, derived from a dynamic user model. This paradigm is founded from, and structured by, pedagogical concerns rather than hardware and software capabilities and, hence, the facility to investigate its validity and explore the process of its implementation via this prototyping approach is particularly valuable.

Philips systematises his approach thus,

fig. 27 Prototype model, the individual author approach.
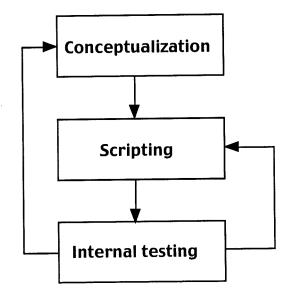
fig. 28 The prototyping process.

These models (figs. 27 & 28) clearly illustrate the hierarchy of the relationship between the user and the developer in this research and developmental phase. The developer is immersed in an iterative prototyping process and, when satisfied that the outcome will be successful, they test the results on a user. The results of these tests may reimmerse the developer in the prototyping process, to a variety of 'depths' dependent upon the success of the user testing, but forward progress is typified by a transition from deep to shallow immersion in the prototyping process, with the resulting final surfacing in the publication phase. Hence, the developer develops and the user confirms or rejects the developers assertions. However, these models do not indicate to what extent personal or situational variables are controlled during the user testing or whether these variables have indeed been considered in the prototyping process. In the discussion above it has been recognised that there is a need for a transition in the hierarchy of the relationship between developer and user. However, a simple model of research and development methods for the design and production phase followed by illuminative methods for the trial and evaluation phase appears to preclude the notion of the user testing enabling the transition from the highly focussed endeavours of the prototyping phase through to the fully naturalistic testing in the trialing phase. The transition between the two phases could be seen as abrupt, disconnected and polarised.

What emerges is the need for the user testing to follow a transitionary path from highly focussed, through quasi-naturalistic, to fully naturalistic and that this transitionary path should run in parallel to the gradual 'surfacing' of the prototype. Such a process would enable the gradual introduction of personal and situational variables into the prototyping phase, in a relatively controlled manner, such that they could form a valid part of the prototyping process. This is essential for this current research as the design specification and the courseware operating paradigm have been founded upon personal and situation variables, i.e. the situation, the task and the pedagogy.

In finally formulating a revised model for the design and production phase it also needs to be recognised that there are essentially two user groups who will use this courseware - teachers and pupils. The concerns of both of these groups must be encompassed in the design and production phase if the personal and situational variables (situation, task and pedagogy) are to form an intrinsic part of the development process and, hence, the final outcome. This recognition of the two user groups introduces a potential problem into the revised developmental model, but may also provide a solution. The problem manifests itself in the typicality of the user chosen, or range of possible users to choose from, and the actual possibilities for introducing ever increasing naturalism into the user testing scenario. If user testing focusses upon the pupil in the design and development phase, and there are high levels of naturalism in the testing scenario, then this phase begins to overlap with the trial and evaluation phase and is in danger of completely merging with it. Such a merged situation would remove the rapid development advantages afforded by an individual author prototyping approach, as the extended iterations required by fully naturalistic testing, or even quasi-naturalistic testing with pupils, would add an undesirable inertia into the process. These issues highlight the need for balance and the careful selection of the 'user' in each of the testing phases.

The modus operandi of a teacher who plans lessons well will encompass the rehearsal of likely events, interactions with, and outcomes from, their plans and developed resources. The teacher makes selections and decisions based upon sound curriculum practice and personal experience. They effectively operate as their own evaluator, or user tester, during their planning phase and will not have the benefit of pupil feedback until after implementation of their plans and resources. Their knowledge and experience of a wide variety of users, who work within the context for which they are planning, enables them to act as a condenser, or focus point, for these many individual users'

potential personal reactions to, and interactions with, resources that are used within their own teaching environment. It is apparent, therefore, that the ability of the teacher to act as both lesson planner and, to some extents, lesson evaluator, even before the lesson takes place, is extremely valuable in the design and production phase of this current and other similar research. What emerges from this discussion is the potential for the teacher to act in a dual role, i.e. teacher as curriculum specialist and teacher as pupil, and that their ability to do this might enable an effective transition between the two phases of this current research. Furthermore, this approach would maintain the levels of forward momentum, in the early stages of the project, that are afforded by research and development and individual author prototyping methods. Essentially, the focus for user testing begins with an individual curriculum provider (developer) during the initial prototyping phase. The focus then broadens to a range of curriculum providers (teachers), who have a developed insight into the potential reactions of curriculum providees (pupils), as the prototype begins to surface. At the point immediately prior to publication, or the commencement of a fully naturalistic, large scale, illuminative trial, the focus for user testing will be shared between curriculum providers (teachers) and curriculum providees (pupils).

This revised model now encompasses the notion of user testing following a transitionary path from highly focussed, through quasi-naturalistic, to fully naturalistic, where this transitionary path runs in parallel to the gradual 'surfacing' of the prototype, and, that the focus for user testing will pass from curriculum provider to curriculum providee as the development process proceeds.
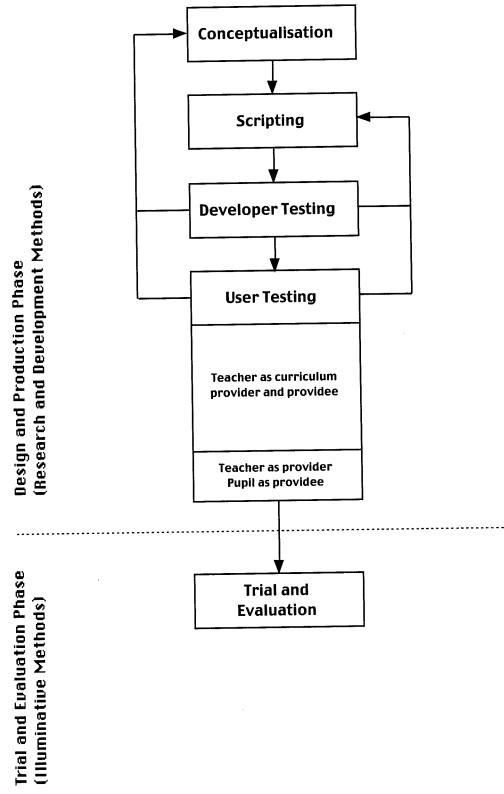
Fig. 29 Developed model for the design and production phase.

The Trial and Evaluation Phase (Illuminative Methods)

In describing their illuminative approach to evaluation Parlett and Hamilton contrast it

with more conventional psychometric traditions, which require high degrees of control

to be applied to the situational and personal variables likely to be encountered in a

naturalistic setting, and highlight the benefits afforded by adopting this alternative

illuminative approach. They classify these methods, in broader terms, as belonging to

either the agricultural-botany or the anthropological paradigm and summarise their

respective relevances. On traditional methods,

> ...applying the agricultural-botany paradigm to the study of innovations is
> often a cumbersome and inadequate procedure. The evaluation falls short of
> its own tacit claims to be controlled, exact and unambiguous... innovations,
> in particular, are vulnerable to manifold extraneous influences. Yet the
> traditional evaluator ignores these. He is restrained by the dictates of his
> paradigm to seek generalised findings along pre-ordained lines. His
> definition of empirical reality is narrow. One effect of this is that it diverts
> attention away from questions of educational practice towards more
> centralised bureaucratic concerns.

(Parlett and Hamilton 1972 p.7-8)

and on illuminative approaches,

> ...illuminative evaluation takes account of the wider contexts in which
> educational programs function. Its primary concern is with description and
> interpretation rather than measurement and prediction... The aims of
> illuminative evaluation are to study the innovatory program: how it
> operates; how it is influenced by the various school situations in which it is
> applied; what those directly concerned regard as its advantages and
> disadvantages; and how students' intellectual tasks and academic
> experiences are most affected. It aims to discover and document what it is
> like to be participating in the scheme, whether as a teacher or pupil; and in
> addition, to discern and discuss the innovation's most significant features,
> recurring concomitants, and critical processes.

(Parlett and Hamilton 1972 p.9)

It is the consideration of these 'extraneous influences', and their clear relationship to the recurring themes of the situation, task and pedagogy in this current research, that suits it to the trial and evaluation phase of this project. Parlett and Hamilton refer to these influences collectively as the 'learning milieu' and assert that, '... innovatory programs, even for research purposes, cannot sensibly be separated from the learning milieux of which they become part.' (Parlett and Hamilton 1972 p.12) Furthermore, as has been discussed in the previous sections of this current work, the 'learning milieux' that this courseware is used within is the major determining factor in its design and, hence, its consideration is vital in making summative evaluative judgments.

In this essentially qualitative paradigm the process by which these learning milieux might become an intrinsic part of the constructed and deployed methodology is not defined by its proponents; rather they characterise their illuminative approach as a 'research strategy' rather than a 'methodological package'. This research strategy can encompass the qualitative methods that are relevant to the situation being investigated, but is normally centred on observation and interviews with the occasional use of questionnaires. These research instruments are deployed in three distinct research phases, which are illustrated below,
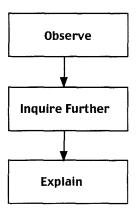
fig. 30 The phases of illuminative evaluation.

How then might these three stages be related to the trial and evaluation phase of this current research? It may be sufficient to adopt this simple linear approach, and apply it in a range of settings that encompass the major aspects of the milieu 'constructed' in the design phase, in order to make summative evaluative judgments on the efficacy of the developed courseware. However, as this milieu has been constructed, on the basis of assertions made around the three principle design criteria of the situation, the task and the pedagogy, then it is the matching of the constructed milieu and the actual milieu that should lead to the most successful deployment and subsequent use of the courseware. Therefore, if the illuminative approach adopted and developed for the trial and evaluation phase of this current research is to be most effective, then it should include features, and utilise research instruments, that can reveal potential matches in the constructed and actual milieu and relate those to the success of the courseware from the users' perspective.

This notion of a match, or mismatch, between the constructed milieu and the actual milieu leading towards teachers adoption or rejection of courseware can be illustrated by identifying the general factors that appear to affect these decisions. In Cates and Cornail-Engel it has already been observed that new courseware innovations should:

1. Match current curricular emphases;

2. Match current teaching practice;

3. Match current instructional time restraints.
(Cates. W. M. 1992 p. 5-6)

And that teachers' willingness to introduce technological innovations by the criteria that

they:

> - *be easy to use, and once in use the technologies will not be being constantly renewed,*
>
> - *fit in well with the teaching methods which have been tested and are valued,*
>
> - *allow the desired objectives to be achieved.*
>
> (Cornail-Engel. I. 1994 p.251)

Voogt arrives at the conclusion that,

> *... at the very first stage of the process leading to the integration of courseware into the curriculum, courseware should motivate students, realise educational objectives better than traditional methods and its content should be an operationalization of teachers ideas and beliefs.*
>
> (Voogt. J. 1990 p.299)

To arrive at this conclusion Voogt cites the work of Fullan and Doyle & Ponder, which

is useful to reproduce here. Voogt describes Fullan's conclusion of how this process of

change functions,

> *The process of educational change has three stages, viz. adoption, implementation and incorporation. Adoption leads to the decision to use an innovation. Implementation is the process of putting a change into practice. Implementation in itself can lead to the incorporation of the innovation in its environment.*
>
> (Voogt. J. 1990 p.299)

Voogt also provides insight into Fullan's view of how teachers decide to adopt,

implement and incorporate innovations,

> ... the quality and practicality of the materials which are part of the
> innovation influence the implementation of an innovation. To promote
> implementation of the integration of courseware in the curriculum,
> knowledge about determinants of quality and practicality of courseware as
> perceived by teachers are of vital importance.

(Voogt. J. 1990 p.299)

Voogt's use of Doyle and Ponder in reaching his own conclusion focuses on Doyle and

Ponders' coining, and use of the term, 'practicality ethic', a concept which is descried as

comprising of,

> ... three general dimensions - instrumentality, congruence and cost...
> Instrumentality refers to how clearly and specifically the innovation is
> presented. Congruence describes how well the innovation is aligned with the
> teacher's present teaching philosophy and practices. Cost is the teacher's
> estimate of the extra time and effort the innovation requires compared with
> the benefits the innovation is likely to yield.

(Voogt. J. 1990 p.299)

There are many further lists of factors available within the literature, but as can be seen

from the examples sited these considerations generally tend to fall within the broad

categories of organisational considerations and educational considerations.

The central role of the teacher in the design and development phase of this current research has been discussed and their ability to act as curriculum provider and providee, or focus point for the providees, recognised as being crucial to the initial construction of the developer's perception of the learning milieu. During the trail and evaluation phase of this current research it becomes clear that the teacher will have a pivotal position in the actual learning milieu. Their perceptions of the courseware, their opinions of its ability to support their curriculum practice in the context in which they work, and, hence, the judgments they make about its quality, will be informed by their use of it with their pupils. However, a single iteration of any new project, resource or scheme of work may only enable shallow conclusions to be drawn as any learning milieu is essentially complex. This complexity may lead to conclusions that focus upon the organisational rather than the educational, as organisational changes brought about by the introduction of the innovation will be immediately evident, but changes in the quality of learning may not become evident until after the trial is complete and the pupils are again working in a similar context. Further iterations are needed if the surface, organisational considerations are to be broken through so that the educational considerations might be investigated. This essential need for iteration is generally recognised in the broadest context of curriculum provision and development as the reflective practice of teachers and their day-to-day role as 'action researchers'.

However, requiring the teacher to be involved in subsequent iterations of the courseware implementation, as a compulsory principle of the trial, could create problems in enabling this transition from organisational to educational considerations in this research phase. If the teacher's opinions of the courseware are poor, then it is unlikely that subsequent iterations will overcome this mismatch. Conversely, teachers who have a good opinion of the courseware are more likely to overcome any organisational

difficulties brought about by the novel situation and, hence, be able to gain a greater depth of insight into the educational processes in subsequent iterations. It is evident that an adoptive approach may be more productive, and hence illuminative, in subsequent iterations of the courseware trial, i.e. teachers elect to take on the courseware to use as their own and integrate it into their 'normal' curriculum practice after the initial trial is completed.

So, in developing the process provided by Parlett and Hamilton, a revised process needs to include: the division of the learning milieu into organisational and education factors; the relative importance of these factors to the phase of the evaluation being undertaken; the concentration on 'adopters' in subsequent iterations; the facility to explain after each iteration; and that subsequent explanations will give an increasingly accurate indication of the research relatability. This developed process is illustrated in the model shown overleaf.

Observe: Range of Learning Milieu
Superior Factors: Organisational Subordinate Factors: Educational

Inquire Further
Superior Factors: Organisational Subordinate Factors: Educational

Explain

Observe: Adopters
Superioer Factors: Educational Subordinate Factors: Organisational

Inquire Further
Superior Factors: Educational Subordinate Factors: Organisational

Explain

Observe: Adopters
Subordinate Factors: Educational Superior Factors: Organisational

Inquire Further
Superior Factors: Educational Subordinate Factors: Organisational

Explain

Increasing levels of research relatability

fig. 31 The developed model for the trial and evaluation phase.

Relatability is of paramount importance to this current research. It has been proposed

that the success of this courseware will be dependent upon the match of the constructed

and actual learning milieu used for the trial. Although on an individual level each milieu

may be complex, this discussion has shown that there are general categories that can be

considered and that may be common. If this were not so then a learning milieu could not

be 'constructed' at the courseware design and development stage. Fortunately, Parlett

and Hamilton, the progenitors of this illuminative approach, provide reassurance.

> *Learning milieux, despite their diversity, share many characteristics.*
> *Instruction is constrained by similar conventions, subject divisions, and*
> *degrees of student involvement. Teachers encounter parallel sets of*
> *problems. Students' learning, participation, study habits, and examination*
> *techniques are found to follow common lines; and innovations, as such, face*
> *habitual difficulties and provoke familiar reactions. There is a wide range of*
> *overlapping social and behavioural phenomena that accompany teaching,*
> *learning and innovating.*
>
> (Parlett. M. and Hamilton. D. 1972 p.28)

The final model for the methodology employed for both distinct phases of this current

research is shown overleaf:

Design and Production Phase (Research and Development Methods)

Trial and Evaluation Phase (Illuminative Methods)

Conceptualisation

Scripting

Developer Testing

User Testing

Teacher as curriculum provider and providee

Teacher as provider
Pupil as providee

Observe: Range of Learning Milieu

Superior Factors: Organisational
Subordinate Factors: Educational

Inquire Further

Superior Factors: Organisational
Subordinate Factors: Educational

Explain

Observe: Adopters

Superioer Factors: Educational
Subordinate Factors: Organisational

Inquire Further

Superior Factors: Educational
Subordinate Factors: Organisational

Explain

Observe: Adopters

Subordinate Factors: Educational
Superior Factors: Organisational

Inquire Further

Superior Factors: Educational
Subordinate Factors: Organisational

Explain

Increasing levels of research relatability

Fig. 32 Methodology model for entire project.

References:

Knussen. C., et al. (1991) An Approach to the Evaluation of Hypermedia - Computers and Education:Pergamon Press:UK - vol.17 no.1

Cates. W. M. (1992) Fifteen Principles for Designing More Effective Instructional
    Hypermedia/Multimedia Products - Educational Technology: December Edition

Cornail-Engel. I. (1994) The School Textbook - Can We Now Throw it Away? -
Educational Media International - vol.31 no. 4

Parlett. M. and Hamilton. D. (1972) Evaluation as Illumination: A New Approach to
the Study of Innovatory Programs - Occasional Paper:Centre for Research in the
Educational Sciences:University of Edinburgh

Phillips. W. A. (1990) Individual Author Prototyping: Desktop Development of
Courseware - Computers and Education:Pergamon Press:UK - vol.14 no. 1

Voogt. J. (1990) Courseware Evaluation by Teachers: An Implementation Perspective -
Computers and Education:Pergamon Press:UK - vol.14 no. 4

Chapter 3 -Operationalising the Research

Section 2 - Project Implementation and Time scale

The Design and Production Phase

The design and production phase of this current research took place between October

1994 and August 1996 with this researcher employing the previously described

individual author prototyping methods. User testing during this phase followed the

model developed in section 1 of this chapter and the transitionary path from highly

focussed, through quasi-naturalistic, to fully naturalistic user testing scenarios was

evident as the courseware prototype 'surfaced'.

The variety of user testing scenarios available to a developer, on an opportunity basis,

will be dependent upon their relationship to the intended end users and their own

professional position. The term 'opportunity basis' is used here to define a situation

whereby user testing can be conducted as the need arises, without the need to gain

permission, negotiate access and conform to institutional time constraints. This is an

important consideration as the rapid development opportunities afforded by the adoption

of this kind of prototyping approach are dependent upon regular user testing, feedback

and developer response. A teacher, acting as a courseware developer, will have a

number of user testing opportunities available to them on an opportunity basis within

their own institutional context. Much of the early prototyping phase might be completed

by using colleagues as user testers. However, as the courseware prototype develops the

need for user testing to encompass a range of learning milieux will necessitate the

setting up of testing scenarios outside of their own institutional context to lend greater

levels of relatability, and reliability, of the resultant courseware outcome. The more

distant those user testing scenarios become from the developer's own institutional

context, the more time is likely to be required to set up the test and incorporate the

developers response to the user feedback. Lone developers working outside of the

institutional context, or contexts, for which their courseware is intended may have far

fewer opportunity based user testing scenarios available to them and, hence, would

potentially be at a disadvantage to a developer working within the institutional context

if this proposed courseware development method is employed. Hence, the efficacy of

the design and production phase of this courseware development method will have

some dependence on the number and range of opportunity based user testing

opportunities that are available to the developer.

This researcher was working in the professional context of a teacher training department

within a higher education institution during the time period covered by this current

research. This professional context provided a broad range of readily available

opportunity based user testing scenarios, which were incorporated into the design and

production phase of the courseware prototype. During the initial phases of courseware

development this researcher was able to take advantage of the steady supply of

practising teachers visiting the department as a normal part of daily operations. It was

also possible to involve colleagues and teacher training students to give a wide variety

of feedback during these initial phases.

Teachers, colleagues and students using the software were encouraged to follow a 'talk

as you go' process, whereby they speak out loud their thoughts as they use the

courseware. This pragmatic approach gives a good level of developer insight into the

immediate thought processes of the user. The outcomes from this testing and feedback

process are not formally recorded as they are meant to provide the developer with action

points that they can rapidly respond to and retest. Moreover, extensive recording and analysis in this phase would not be concomitant with the development methodology proposed as it would add an unnecessary inertia into the developmental process in the early phases of the development of the courseware prototype. However, the major outcomes from these tests are evident in the various iterations of the courseware prototype and are discussed more fully in section 3 of this chapter.

As a workable courseware prototype began to surface it became appropriate to broaden the scope of user tests from individuals testing the courseware in the presence of the developer to groups using the courseware for the completion of tasks. This researcher was able to undertake this next phase of user testing, on an opportunity basis, by using the courseware with a group of 20 Post Graduate Certificate in Education students, and, in so doing, the user testing scenario used began the necessary transition from highly focussed individual use to a quasi-naturalistic setting. This was a very useful intermediate user testing scenario as the integrity of the courseware operation and content could be rapidly established by using 'teachers' in their previously described dual role of curriculum providers and providees. In common with the first phase of user testing the outcomes from this user testing stage are evident within the subsequent iterations of the courseware prototype and are discussed more fully in section 3 of this chapter. This intermediate user testing phase enabled the development of a fully working courseware prototype that was suitable to be tested in a fully naturalistic setting in the final phases of this design and production phase.

The final phase of user testing took place in a school situation with a group of year 9 pupils using the courseware in the completion of a project which formed a normal part of their Design and Technology work. Hence, the scenario encompassed as many of the components of the learning milieu as possible with the teacher and pupils acting, and providing feedback, in their roles as curriculum provider and providees respectively. Again this user testing phase concentrated upon the integrity of the content and

operation of the courseware prototype, but this feedback was enriched by the

organisational conditions brought about by the naturalism present within that scenario.

This final phase of user testing enabled the trial and evaluation phase to be entered with

some confidence with respect to the integrity of the courseware and for early testing of

feedback instruments to be undertaken. This user testing phase led to one final iteration

of the courseware prototype which is described in section 3 of this chapter.

The Trial and Evaluation Phase

The trail and evaluation phase of this current research took place during the school year

1996 to 1997. The basis for attaining a good degree of relatability in the results from the

illuminative approaches used during this phase relied upon the adoption of the

courseware prototype by users and its integration into subsequent curriculum practice.

This adoption, and the subsequent second round of testing, enabling a greater depth of

analysis to take place with respect to the educational aspects of the learning milieu of

the testing scenario. For these reasons the trial and evaluation phase commenced at the

beginning of the school year. Introducing the courseware at this point might naturally

stimulate the adoption of it as teachers plan their forthcoming schemes of work for the

whole year, and it provides the opportunity for its adoption whilst the experience of the

first trial is still 'hot'. Three schools were selected to take part in the trial and evaluation

phase of this current research, which represented a range of learning milieu relating to

the three principle design criteria for the courseware prototype. All schools participating

in the first trial subsequently adopted the courseware and were willing to participate in

the second trial. Information regarding the implementation of the trial that was sent out

to schools is available in appendix 1. This information covers the key points of the

courseware operation and the project sequencing. It stresses the critical interactions that

pupils must have with the courseware if it is to maintian its integrity, e.g. logging-on,

printing and visit completion. It provides teachers with a set of six over-head projector slides, and associated notes, to enable them to introduce the courseware to their pupils. It also provides information about all passwords and administration tools associated with the courseware. All teachers were visited prior to them agreeing to trial the courseware so that it could be demonstrated to them. They were also left with an evaluation copy and were encouraged to use it in order that they could develop sufficient familiarity with it to use it confidently with their teaching groups. Contact details for this researcher were also provided so that support could be given in the event of difficulties being encountered.

Two principal research instruments were developed for the first iteration of the trial:

1. A suite of tools to extract the user model data from the courseware (more detailed information available in section 4 of this chapter).

2. A semi-structured interview schedule for gaining feedback from teachers. The content of this interview schedule concentrated upon the organisational aspects of the learning milieu and their relationship to the courseware design.

The second trial concentrated upon the adopters of the courseware. Research instrument 1 was reused. A new semi-structured interview schedule was devised that concentrated upon the educational aspects of the learning milieu and their relationship to the courseware design. (more detailed information is available on both interview schedules in section 4 of this chapter)

At the end of each trialling phase:

• the used courseware was collected for subsequent extraction and analysis of the user model information;

• the participating teachers were interviewed using the appropriate interviewing schedule. The interviews were tape recorded and subsequently transcribed for later analysis.

The sequence and time periods of all of these activities are indicated alongside the previously developed methodology model for this current research project in the diagram shown overleaf.

Design and Production Phase (Research and Development Methods)

Trial and Evaluation Phase (Illuminative Methods)

Increasing levels of research relatability

Conceptualisation

Scripting

Developer Testing

User Testing

Teacher as curriculum provider and providee

Teacher as provider
Pupil as providee

October 1994 - Beginning of the courseware prototyping process

Individual user testing by teachers as required and on an opportunity basis

October 1995 - First full working prototype completed

Testing with 20 PGCE students working to complete a project

April 1996 - Version 1.0

Testing in a school based scenario

August 1996 - Version 1.01

Observe: Range of Learning Milieu

Superior Factors: Organisational
Subordinate Factors: Educational

September 1996

1st Trial commenced in 3 schools

Used courseware collected

Inquire Further

Superior Factors: Organisational
Subordinate Factors: Educational

Explain

January 1997

2nd Trial commenced with courseware adopters

Used courseware collected and teachers interviewed about the first trial.

Observe: Adopters

Superioer Factors: Educational
Subordinate Factors: Organisational

Inquire Further

Superior Factors: Educational
Subordinate Factors: Organisational

Explain

May - August 1997

2nd Trial completed and courseware adopting teachers interviewed about the second trial.

Observe: Adopters

Subordinate Factors: Educational
Superior Factors: Organisational

Inquire Further

Superior Factors: Educational
Subordinate Factors: Organisational

Explain

Fig. 32 Methodology model for entire project (with dates).

Chapter 3 - Operationalising the Research

Section 3 - Instantiating the Courseware

The instantiation of the courseware was guided by the general principles developed from the discussion in chapter two and principly structured by the courseware development paradigm established, i.e.the sequential combination of cognition clusters supported by system intelligence derived from a dynamic user model; the resulting stages in the process of courseware design being previously stated as,

1. Break the overall task down into task stages that can be facilitated by a cognition cluster.

2. Begin 'growing' the cluster by:

a. specifying the nature of the excursions that will be made available from each stage node;

b. specifying the nature of orientation nodes that will be made available on repeat visits to a stage node;

c. formulating the criteria that will enable transfer from one stage to the next.

3. Build the courseware by sequencing the cognition clusters and decide whether the intercluster links are mono or bidirectional.

4. Decide upon how the intelligence outcome might be manifested and where and what intelligence income will need to be sought.

The instantiation of the courseware followed a process of prototyping the resultant

clusters and developing the system intelligence to support their operation. User testing

was incorporated into this prototyping process in the manner suggested by the

discussion in section 1 of this chapter. A fuller explanation of the timescale and

operation of this process is given in section 2 of this chapter.

The courseware development platform chosen was hyperCard running on an Apple

Macintosh computer. As has been described earlier, hyperCard is a package that

combines the user interface of the Macintosh, with a suite of powerful multimedia

authoring tools and a high-level, object oriented programming language known as

HyperTalk. This is a well documented and extensively used application prototyping

platform as is attested to by the extensive range of 'third-party' manuals that are

available and the number of research studies evident within the literature that employ it.

This researcher found a number of information sources to be of use in this phase of this

current research, principally:

• For the generic concepts of good hyperCard 'stack' design and effective user testing

during a prototyping phase - HyperCard Stack Design Guidelines published by Apple

Computer inc. through Addison-Wesley. (Apple Computer inc. 1989)

• For the rapid development of programming skills necessary to prototype this

intelligent courseware, and for unleashing the full potential of HyperCard - Coulouris

and Thimbleby's excellent HperProgramming: Building interactive programs with

HyperCard.

(Coulouris and Thimbleby 1992)

• For providing answers to programming problems, where the literature was incapable

of doing so, either due to simple omission or lack of context sensitivity in concept

explanation - The USENET newsgroup 'populated' by the world's HyperCard experts:

comp.sys.mac.hypercard

It is the object oriented programming language (HyperTalk) contained within

HyperCard that elevated this package above its immediate competitors, such as Guide

or Toolbook. These packages are perfectly capable of producing relatively complex

networks of infomation nodes and links and of incorporating a variety of media within

these nodes. However, because they only have the most basic of abilities to 'pass

messages' from one object to another and to execute these messages when 'received',

the structure, content and operation of the information networks are necessarily largely

static. HyperTalk enables comprehensive message passing between the objects withing

the information network and the execution of the messages via individual programs

known as handler scripts. HyperTalk can, therfore, enable the dynamic construction and

modification of content and the dynamic linking of nodes. In essence HyperTalk can be

used to build the sytem intelligence required by this courseware prototype.

It is interesting to note that subsequent packages and platforms have used the concepts

and operational characteristics of HyperCard as the basis for their own operation, e.g.

Macromedia Director with LINGO, or they have been added later as a result of

functional need, e.g. HTML with JavaScript.

The process of developing the courseware prototype was naturally subdivided by the underlying concept of the sequential combination of cognition clusters. However, this researcher found it helpful to further subdivide the development process as some cognition clusters grew to considerable sizes in their own right. This was achieved by saving a new version of the courseware after a major development in operation was instantiated or a new section of content included. This process results in a 'history' of versions being collected, which enables backtracking by major steps if the subsequent developments prove to be misdirected or if a catastrophic, or undebuggable, fault occurs.

These development versions of the courseware prototype can be found on the included CD-ROM and are labelled variously as, 'log on 1', 'Developer 1 to 28' and subsequently 'electronics designer 1.0 to 1.02. It should be noted that to 'run' any version of the courseware they should be copied to a writable hard disk so that the usermodel can be updated by the system. The hard disk must contain a full version of HyperCard as the courseware has not been compiled as a stand-alone application. It should also be noted that early versions may contain unimplemented paths or faulty code and that some sound timings may be inconsistent with screen displays on very new and fast machines. On later versions of the courseware you may be asked for a password after booting. The password is 'applepower'.

This researcher also found that as the courseware prototype grew by the development and addition of cognition clusters, and the increasing functionality of the system intelligence, it became helpful to construct a physical map of the courseware node and link structure. It is not uncommon for developers to do this, but it was particularly useful for this current research in its early phases as the map enabled a good

visualisation of the cognition clusters, and the associated excursions avaiable to

individual users, to be obtained. All possible screens were included in the map and

colour coded links were applied for differing user models. This map was instantiated

after the the completion of cognition cluster one and was maintained until the

completion of cluster 3. By this time the map was growing to unmanageable proportions

and some rationalisation had taken place as all possible screens could not be practically

included. It was subsequently abandoned as maintaining it began to impede rather than

augment progress.

The development of the courseware prototype is described on the following pages

cluster by cluster. An indication of the version numbers relating to these developmental

stages is given and the process and effects of user testing are highlighted. It is useful to

read this section in conjunction with the general cognition cluster definitions provided

in chapter 2. The cognition cluster diagrams from that chapter have been reiterated to

aid the subsequent descriptions of the prototyping process.

Cluster 1


```
                    ┌─────────────────────────────┐      Intelligence income:
                    │           Log On            │      New user model instantiated
                    │  instantiate a new user model│     Users system recorded
                    └─────────────────────────────┘
                                  │                       Intelligence Outcome:
                                  ▼                       Some personalisation of the PCB
                    ┌─────────────────────────────┐
                    │            Tour             │
                    │   familiarise the new user   │
                    │     with the environment     │
                    └─────────────────────────────┘
                                  │
                                  ▼
          ┌──────────────────────────────────────────┐
          │                 Concept                    │
          │  explain, reiterate or reorient about what │
          │    the courseware will enable them to do   │
          └──────────────────────────────────────────┘
                                  │
                                  │              ( Excn )    5 input options
                                  │                          (1 has sub-option)
  System Design                   │
  Stage Node Dynamic content:    ( Stage ) ──────────► [ Act ] ──► Realisation
  Guidance about what to do
  Feedback about effects of decisions                 Printed Circuit Board
                                  │
                                  ▼              ( Excn )    3 output options
```

Fig. 22 Cognition Cluster One.

The courseware prototyping process began in cluster one with the development of a 'Log-On' routine to instantiate a new user model and to set in train the process and practice of data storage that would serve to construct the user model. This data could then be utilised on future invocations of the user model on subsequent visits. The user model derived from, and subsequently developed by, this collected data is of fundamental importance to the correct functioning of the courseware in a context and user sensitive manner. It was, therefore, important to develop a routine that was as mistake proof as possible but which was still easy to operate. There was an obvious temptation to provide each user with a pass-word, but it was finally decided that this would contravene the general principles of a practicality ethic as far as teachers were concerned as the issuing and subsequent remembering of passwords by pupils would be very costly in terms of curriculum time. It would also require a considerable system overhead to store and access the appropriate passwords. It was decided that a user model would be instantiated on the basis of a user providing a first AND last name. This would provide sufficient uniqueness in virtually all settings and would overcome the need for pass-word administration. However, as an aid to both groups of users, i.e. pupils and teachers, it was decided that an information bar would be included at the top of the screen. This could give a rapid indication of who should be using the computer and when that user logged on. This information bar could also contain scrolling or dynamic messages which would aid the user in the courseware operation. The log-on routine was written as a script in the stack background as this is the top level of the message passing hierarchy and can, hence be accessed from all levels. Data collected as a result of the log-on process was stored in a collection of background fields. It was not completely evident at this stage what data would be needed in the future for the development of the user model or how it might be subsequently used for analysis after extraction from the courseware. Furthermore, using fields as the method of data storage limits the size of the data set to 30 000 characers. Consequently the nature of the stored data changes with some iterations of the courseware prototype as problems are

encountered, possibilities arise and concepts are firmed up. It should also be noted that during this time frame there were still many Macintosh computers being used in schools that had a 9 inch monitor. It was therefore decided that this should be the default card size in order that the number of potential trialling environmnets could be maximised.
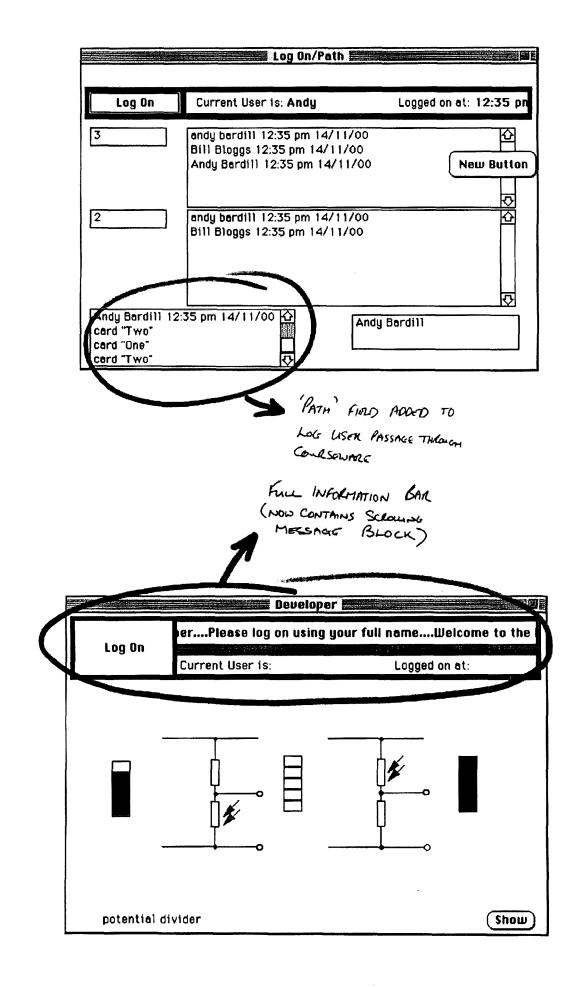
The files 'log on 1', 'log On/Path', 'developer' and 'developer 1' contain the development of the log on routine, the screen top information bar, and the background fileds for the storage of data that is used to derive the user model. At this stage the data is characterised by a list of previous users and their individual paths followed through this first cluster. During this phase the node contents are simply the developers musings and experiments about what may be possible or desirable in the future. A significant change is seen in 'developer 2' when the node contents now begin to reflect the content as defined by cognition cluster 1. However it is not until developer 3 that the cluster content can be seen in its entirety.

```
╔═══════════════════════ Log On/Path ═══════════════════════╗
║                                                            ║
║  ┌──────────┐  ┌──────────────────────────────────────────┐
║  │  Log On  │  │ Current User is: Andy      Logged on at: 12:35 p║
║  └──────────┘  └──────────────────────────────────────────┘
║                                                            ║
║  ┌────────┐  ┌──────────────────────────────────────┬──┐  ║
║  │ 3      │  │ andy bardill 12:35 pm 14/11/00        │⬆ │  ║
║  └────────┘  │ Bill Bloggs 12:35 pm 14/11/00         └──┘  ╭──────────╮
║              │ Andy Bardill 12:35 pm 14/11/00             │New Button│
║              │                                            ╰──────────╯
║              │                                       ┌──┐  ║
║              └──────────────────────────────────────┴⬇─┘  ║
║  ┌────────┐  ┌──────────────────────────────────────┬──┐  ║
║  │ 2      │  │ andy bardill 12:35 pm 14/11/00        │⬆ │  ║
║  └────────┘  │ Bill Bloggs 12:35 pm 14/11/00              ║
║              │                                            ║
║              │                                            ║
║              │                                       ┌──┐  ║
║              └──────────────────────────────────────┴⬇─┘  ║
║  ┌─────────────────────────────┬──┐   ┌──────────────────┐║
║  │Andy Bardill 12:35 pm 14/11/00│⬆│   │ Andy Bardill     │║
║  │card "Two"                    │▓│   │                  │║
║  │card "One"                    │ │   │                  │║
║  │card "Two"                    │⬇│   └──────────────────┘║
║  └─────────────────────────────┴──┘                       ║
╚════════════════════════════════════════════════════════════╝
```

'PATH' FIELD ADDED TO LOG USER PASSAGE THROUGH COURSEWARE

FULL INFORMATION BAR (NOW CONTAINS SCROLLING MESSAGE BLOCK)

```
╔═══════════════════════ Developer ═══════════════════════╗
║  ┌──────────┐  ┌─────────────────────────────────────────┐
║  │          │  │er....Please log on using your full name....Welcome to the║
║  │  Log On  │  ├─────────────────────────────────────────┤
║  │          │  │ Current User is:          Logged on at:  │
║  └──────────┘  └─────────────────────────────────────────┘
║                                                          ║
║                                                          ║
║          ▐█▌      ┌┐         ┌┐        ┌┐     ▐█▌         ║
║          ▐█▌      ││  ╱      ││        ││ ╱   ▐█▌         ║
║          ▐█▌      ││ ╱       ││        ││╱    ▐█▌         ║
║          ▐█▌      └┘○        └┘        └┘○    ▐█▌         ║
║          ▐█▌      ┌┐╱        ┌┐        ┌┐╱    ▐█▌         ║
║          ▐█▌      ││ ╱       ││        ││ ╱   ▐█▌         ║
║          ▐█▌      └┘○        └┘        └┘○    ▐█▌         ║
║                                                          ║
║  potential divider                            ╭──────╮   ║
║                                               │ Show │   ║
║                                               ╰──────╯   ║
╚══════════════════════════════════════════════════════════╝
```

Developer 2

Log On	g on using your full name....Welcome to the Electronics De
	Current User is: Logged on at:

3   andy bardill

Please Log On to

Please Log On using your full name

Charlie Clegg

OK   Cancel

00

Delete

Hide

fred flint
14/11/
bernie ecc
14/11/00

3

fred flin
14/11/00
bernie ec
14/11/00
andy bardill 2:00 pm 14/11/00

936 seconds
card "system3" 1:00 pm
5 seconds
card "system4" 1:00 pm

START OF LOG ON ROUTINE

Developer 2

Log On	g on using your full name....Welcome to the Electronics De
	Current User is: Logged on at:

3   Charlie Clegg

Logging on – Charlie Clegg

**Please check the spelling of your name
Is it correct?**

NO   YES

00

Delete

Hide

fred flint
14/11/0
bernie ec
14/11/00

3

fred flint
14/11/00
bernie ecc
14/11/00
andy bardill 2:00 pm 14/1

936 seconds
card "system3" 1:00 pm
5 seconds
card "system4" 1:00 pm

NAME CHECKING:
CLICKING ON 'NO' EXITS
THE ROUTINE

Developer 2

Log On	g on using your full name....Welcome to the Electronics De
	Current User is: Logged on at:

3 | Charlie Clegg

fred flint
14/11/00
berni ec
14/1 /00

3

fred fli
14/11/0
bernie ec
14/11/00
andy bardill 2:00 pm 14/

Logging on – Charlie Clegg

**Please check the spelling of your name
Is it correct?**

[NO]   [YES]

Delete
Hide

936 seconds
card "System   1:00 pm
5 seconds
card "system4" 1:00 pm

NAME CHECKING :
CLICKING ON 'YES'
CHECKS WITH USER LIST
FOR A MATCH

Developer 2

Log On	g on using your full name....Welcome to the Electronics De
	Current User is: Logged on at:

3 | Charlie Clegg

fred flint
14/11/00
bernie ec
14/11/

3

fred flint
14/11/00
bernie ec
14/11/00
andy bardill 2:00 pm 14/   /00

Please Log On to

Are you a new user?

[NO]   [YES]

Electronics Designer

Delete
Hide

36 seconds
card "System3" 1:00 pm
5 seconds
card "system4" 1:00 pm

NAME CHECKING:
NO MATCH WITH THE USER LIST
WILL CREATES A NEW USER MODEL
CLICKING 'NO' GIVES AN OPTION
TO TRY LOGGING ON AGAIN

CLICKING 'NO' WILL EXIT
THE ROUTINE

CLICKING YES WILL
RETURN TO THE START
OF THE ROUTINE

Developer 2

Log On

g on using your full name....Welcome to the Electronics De

Current User is: Logged on at:

3   Charlie Clegg

fred flin
14/11/00
bernie ecc
14/1 /00

Please Log On using your full name

Charlie Clegg

OK   Cancel

3

fred f nt:
14/11/
bernie ecc
14/11/00
andy bardill 2:00 pm 4/11/00

936 seconds
card "system3" 1:00 pm
5 seconds
card "system4" 1:00 pm

00

Delete

Hide

START OF LOG ON ROUTINE

Developer 2

Log On

g on using your full name....Welcome to the Electronics De

Current User is: Logged on at:

3   Charlie Clegg

fred flint
14/11/00
bernie ecc
14/11/00

gging on – Charlie Clegg

Please check the spelling of your name
Is it correct?

NO   YES

3

fred flint
14/11/00
bernie ecc
14/11/00
andy bardill 2:00 pm 4/11/00

936 seconds
c   1:00 pm
onds
card "system4" 1:00 pm

00

Delete

Hide

NAME CHECKING:
CLICKING ON 'YES' CHECKS
WITH THE USER LIST
FOR A MATCH

```
┌─────────────────────────────────────────────────────────┐
│                      Developer 2                          │
│  ┌──────────┬──────────────────────────────────────────┐ │
│  │          │ g on using your full name....Welcome to   │ │
│  │  Log On  │ the Electronics De                        │ │
│  │          ├──────────────────────────────────────────┤ │
│  │          │ Current User is:           Logged on at:  │ │
│  └──────────┴──────────────────────────────────────────┘ │
│                                                           │
│  ┌─────┬──────────────────────┐                          │
│  │ 3   │ Charlie Clegg         │                    ▲    │
│  ├─────┴──────────────────────┤  Please Log On to   │    │
│  │ fred flint                  │                     │    │
│  │ 14/11/00                    │                00   │    │
│  │ bernie ec  Are you a new user?                         │
│  │ 14/11/00                                               │
│  ├──────      ┌────────┐   ┌────────┐         ┌────────┐  │
│  │ 3          │   NO   │   │  YES   │         │ Delete │  │
│  ├──────      └────────┘   └────────┘         └────────┘  │
│  │ fred flint  Electronics Designer           ┌────────┐  │
│  │ 14/11/00                                    │  Hide  │  │
│  │ bernie ec                                   └────────┘  │
│  │ 14/11/00                      card "System3" 1:00 pm    │
│  │ andy bardill 2:00 pm 14/11/00 5 seconds            ▼    │
│  └──────────────────────────────┘card "system4" 1:00 pm   │
└───────────────────────────────────────────────────────────┘
```

NAME CHECKING:
NO MATCH WITH THE USER LIST
WILL CREATE A NEW USER
CLICKING 'YES' CREATES THE
MODEL AND LOGS THE USER IN

1st LOG IN COMPLETE

LOG BUTTON
CHANGES STATE

INFORMATION BAR
UPDATED

```
┌───────────────────────────────────────────────────────────┐
│                      Developer 2                            │
│  ┌──────────┬──────────────────────────────────────────┐   │
│  │          │        Electronics Designer               │   │
│  │  Log Off │                                           │   │
│  │          ├──────────────────────────────────────────┤   │
│  │          │ Current User is: Charlie   Logged on at: 11:54 am │
│  └──────────┴──────────────────────────────────────────┘   │
│           Welcome to the Electronics Designer               │
│                 You have been logged on as                  │
│                                                             │
│                      Charlie Clegg                          │
│                                                             │
│     You will need to log on each time you use the program.  │
│                                                             │
│        Please use the mouse to press the 'Start' button     │
│                                                             │
│                      ┌────────────┐                         │
│                      │   START    │                         │
│                      └────────────┘                         │
│                                          ┌──────┐           │
│                                          │ Show │           │
│                                          └──────┘           │
└───────────────────────────────────────────────────────────┘
```

SCREEN 1 OF CLUSTER 1

```
═══════════════ Developer 2 ═══════════════

┌──────────────┬──────────────────────────────────┐
│              │     Electronics Designer         │
│   Log Off    ├──────────────────────────────────┤
│              │  Current User is: Charlie     Logged on at: 11:56 am │
└──────────────┴──────────────────────────────────┘

┌─────┐  ┌──────────────────┐
│ 5   │  │ Charlie Clegg     │
└─────┘  └──────────────────┘

14/11/00                            4  seconds
andy bardill 2:00 pm 14/11/00       card "First" 12:44 pm
Charlie Clegg 11:54 am 21/11/00     fred flintstone 12:44 pm 14/11/00
Charlie Clegg 11:56 am 21/11/00     14 seconds
┌─────┐                             card "Introduction" 12:44 pm
│ 4   │                             12 seconds
└─────┘                             card "system" 12:44 pm
                                    2 seconds                    ( Delete )
fred flintstone 12:44 pm            card "System2" 12:44 pm      ( Hide )
14/11/00                            936 seconds
bernie eccleston 1:12 pm            card "System3" 1:00 pm
14/11/00                            5 seconds
andy bardill 2:00 pm 14/11/00       card "system4" 1:00 pm
Charlie Clegg 11:54 am 21/11/00
```

PATH FIELD INFORMATION EXPANDED TO INCLUDE TIME SPENT ON CARD. LATER MODIFIED AS 30,000 FIELD CHARACTER LIMIT IS REACHED TOO QUICKLY

User testing and feedback began from the completion of developer 2 and was centred upon the teacher as curriculum provider and providee as described in section 1 of this chapter. Teachers using the courseware were asked to follow a 'talk as you go' process, whereby they speak out loud their thoughts as they use the courseware. This type of user testing and feedback was employed until the first complete version of the courseware prototype, developer 28 was completed. The results of, and associated modifications brought about by, the user testing and feedback are evident in the various iterations of the courseware prototype.

From developer 2 to developer 3:

• a log-off stimulus was added to encourage people to log-off after they had finished using the courseware. Logging off is a critical part of the user model building process and users felt that this would be a useful addition;
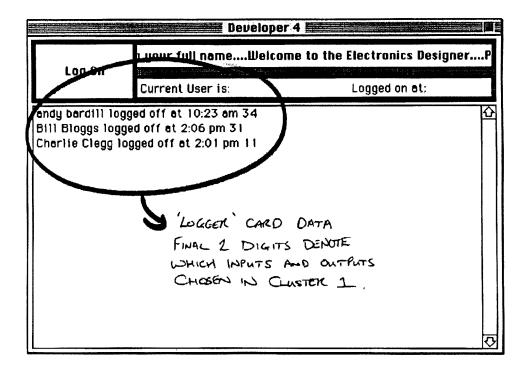
Developer 3		
Log Off	**Electronics Designer**	
	Current User is: bill	Logged on at: 1:49 pm

Always remember to log off when you have finished using the program.

Show

Log off Stimulus - Augmented by Fade in/out of text and human voice 'Reading' the text
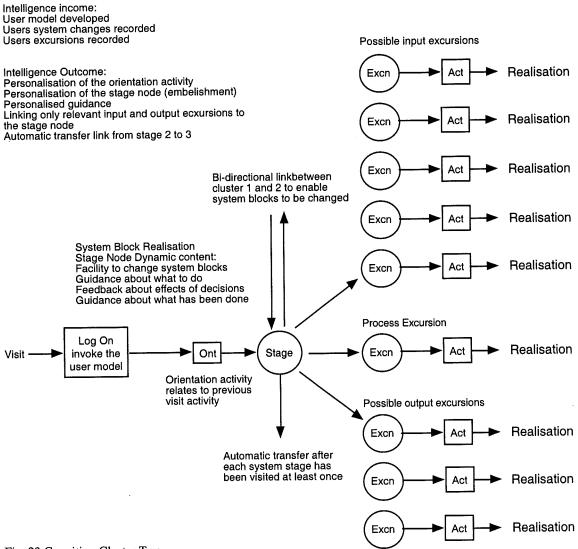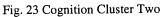
• the sound was changed from a male to female voice. Users had difficulty in hearing the male voice over background noise and felt this this would be exacerbated when used in a school workshop. All other sounds were reviewed and changed as necessary to overcome this difficulty.

Developer 3 shows the first manifestation of the system intelligence outcome by providing some personalisation to the PCB node. By this stage the courseware is intelligent enough to recognise a previous user who has completed the first cluster and can, hence, establish the link to the second. However, the user model is insufficiently detailed to enable the intelligence outcomes required for the operation of cluster 2. The user model must be enriched with data that pertains to the decisons taken about the operation of the input and ouput blocks by the user. This was achieved in developer 4 by the addition of a logger node. Data stored on this node includes the user name, the time they logged off and a numerical code that identifies the input and output blocks that they have chosen.

Developer 4

Login

your full name....Welcome to the Electronics Designer....P

Current User is: Logged on at:

andy bardill logged off at 10:23 am 34
Bill Bloggs logged off at 2:06 pm 31
Charlie Clegg logged off at 2:01 pm 11

'Logger' Card Data
Final 2 Digits Denote
Which Inputs And Outputs
Chosen In Cluster 1.

Cluster 2

Intelligence income:
User model developed
Users system changes recorded
Users excursions recorded

Possible input excursions

Intelligence Outcome:
Personalisation of the orientation activity
Personalisation of the stage node (embelishment)
Personalised guidance
Linking only relevant input and output ecxursions to
the stage node
Automatic transfer link from stage 2 to 3

Bi-directional linkbetween
cluster 1 and 2 to enable
system blocks to be changed

System Block Realisation
Stage Node Dynamic content:
Facility to change system blocks
Guidance about what to do
Feedback about effects of decisions
Guidance about what has been done

Visit → | Log On invoke the user model | → | Ont | → (Stage)

Orientation activity
relates to previous
visit activity

Automatic transfer after
each system stage has
been visited at least once

(Excn) → | Act | → Realisation

(Excn) → | Act | → Realisation

(Excn) → | Act | → Realisation

(Excn) → | Act | → Realisation

(Excn) → | Act | → Realisation

Process Excursion

(Excn) → | Act | → Realisation

Possible output excursions

(Excn) → | Act | → Realisation

(Excn) → | Act | → Realisation

(Excn) → | Act | → Realisation

Fig. 23 Cognition Cluster Two

Developer 5 has sufficient intelligence to recognise a previous user, their progress

through cluster 1 and the decisions that they took about the operation of the input and

output blocks. It successfully invokes an existing user model, greets the user with the

first generic alarm system orientation activity, records the results and presents a

personalised stage node that dynamically reflects the decisions that the user took during

their first visit. The two way link is established between cluster 1 and cluster 2 to enable

users to revisit the cluster 1 excursions if they wish to change their decisions about input

and output blocks. In Developer 6 the link is established to the input, process and output

block excursions although the content is not added. In Developer 7 the user model is

further enriched by extending the data that is stored on the logger node. This now

includes data about the last excursion and its associated activity that the user will have

undertaken. It also records a 'history' of the system blocks that have been completed.
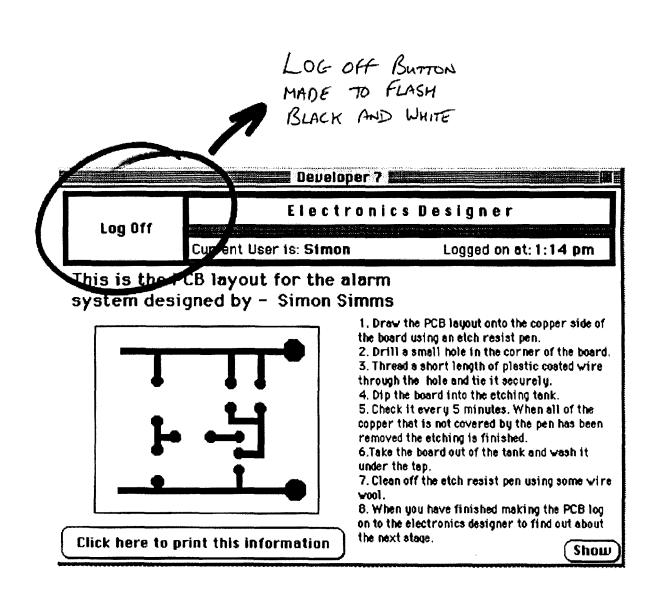
From Developer 3 to Developer 5:

• from user testing it became evident that users might log off before a visit is completed.

This premature log off would compromise the integrity of the user model. To overcome

this difficulty the log off button was hidden until the end of the first visit; a principle

that was adopted for all subsequent clusters.
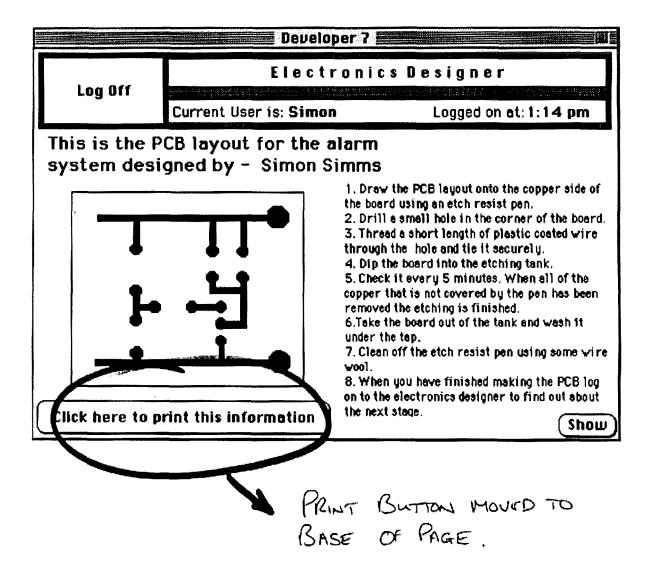
From Developer 5 to Developer 7:

• users were sometimes still unsure that they should log off at the end of the first visit.

To prompt a log off the log off button was made to flash steadily.

LOG off BUTTON
MADE TO FLASH
BLACK AND WHITE

Developer 7

Electronics Designer

Log Off

Current User is: Simon   Logged on at: 1:14 pm

This is the PCB layout for the alarm
system designed by - Simon Simms

1. Draw the PCB layout onto the copper side of
the board using an etch resist pen.
2. Drill a small hole in the corner of the board.
3. Thread a short length of plastic coated wire
through the hole and tie it securely.
4. Dip the board into the etching tank.
5. Check it every 5 minutes. When all of the
copper that is not covered by the pen has been
removed the etching is finished.
6. Take the board out of the tank and wash it
under the tap.
7. Clean off the etch resist pen using some wire
wool.
8. When you have finished making the PCB log
on to the electronics designer to find out about
the next stage.

Click here to print this information

Show

• users were confused by the position of the print button on the PCB page. They were unsure whether to print the page before reading the information and often forgot to print it after reading the information. This was removed and the button was repositioned to the bottom of the page so that it is naturally viewed after reading the information.

```
═══════════════════════════ Developer ? ═══════════════════════════
┌─────────────┬──────────────────────────────────────────────────┐
│             │            Electronics Designer                  │
│   Log Off   │                                                  │
│             ├──────────────────────────────────────────────────┤
│             │ Current User is: Simon      Logged on at: 1:14 pm │
└─────────────┴──────────────────────────────────────────────────┘
```

This is the PCB layout for the alarm
system designed by - Simon Simms

1. Draw the PCB layout onto the copper side of the board using an etch resist pen.
2. Drill a small hole in the corner of the board.
3. Thread a short length of plastic coated wire through the hole and tie it securely.
4. Dip the board into the etching tank.
5. Check it every 5 minutes. When all of the copper that is not covered by the pen has been removed the etching is finished.
6. Take the board out of the tank and wash it under the tap.
7. Clean off the etch resist pen using some wire wool.
8. When you have finished making the PCB log on to the electronics designer to find out about the next stage.

Click here to print this information

Show

PRINT BUTTON MOVED TO BASE OF PAGE.

• users were seen to click out of the courseware window when the coursware was run on a monitor that was larger than 9 inches; the effect being to lose the courseware window behind any open finder windows. Users reported that this was a problem that they had sometimes experienced with other software when used with pupils. The solution was provided via a post to comp.sys.mac.hypercard. An external resource for use with HyperCard called DeskCover1.1 was downloaded from the UMICH FTP archive mirror at Imperial College. This covers any exposed desktop with a grey tone when installed into, and called from, the current stack preventing a user from bringing the finder to the front by clicking on the desktop.
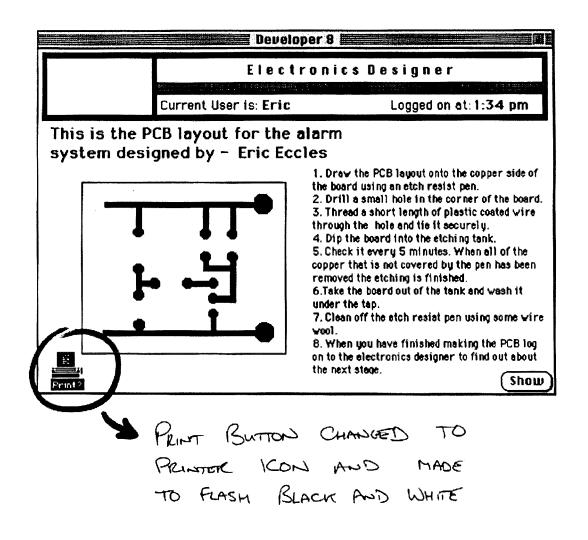
• users became confused if they followed the link back to the first cluster. When

returning to the second cluster they were taken back to the main stage node which was

insufficiently different for them to immediately notice the transition or they became

sufficiently confused to entere a circular loop, jumping between the main stage nodes of

cluster 1 and 2. To overcome this problem the link back to cluster 2 takes the user on to

the input, process and output block linking points.

NAVIGATION   LINKS   CHANGED FROM THIS:

TO   THIS:

TO AVOID DISORIENTATION AND POTENTIAL
FOR CIRCULAR LOOPING.

In Developer 8 the input content for the window/door switch and the pressure mat was added. During user testing:
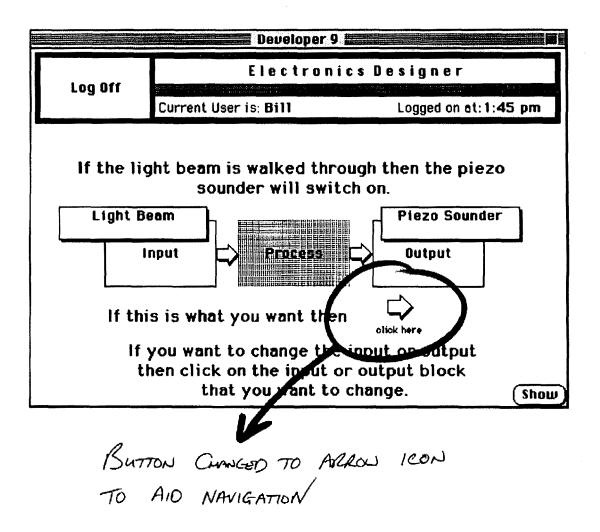
• users remarked on the presence of the menu bar. Some 'mischievous' testers were able to edit the courseware. The menuBar was hidden from view when the courseware is opened.

• Some users were still missing the print button on the PCB page. The button was modified to resemble a printer icon and made to flash. This concept was subsequently adopted for all other print buttons in the courseware.

Print Button Changed to Printer Icon And Made To Flash Black And White
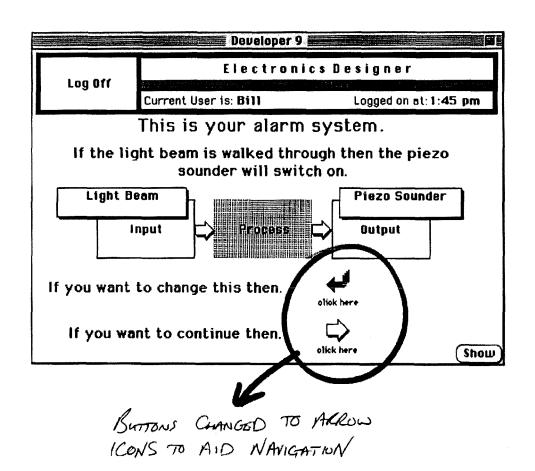
In Developer 9 the input content for the light beam was added. During user testing:

• users were still experiencing some confusion when presented with the links from the

main stage node of cluster 2. This was the case for both the continue to PCB link and

the cluster 1 revisit link. The buttons were modified to arrow icons to represent forward

progress or back up to another level.

Developer 9

	Electronics Designer
Log Off	
	Current User is: Bill Logged on at: 1:45 pm

**If the light beam is walked through then the piezo
sounder will switch on.**

Light Beam		Piezo Sounder
Input	Process	Output

If this is what you want then ➪
click here

**If you want to change the input or output
then click on the input or output block
that you want to change.**

(**Show**)

Button Changed To Arrow Icon
To Aid Navigation

```
═══════════════ Developer 9 ═══════════════

┌──────────┬──────────────────────────────────┐
│          │      Electronics Designer        │
│  Log Off │                                  │
│          │ Current User is: Bill    Logged on at: 1:45 pm │
└──────────┴──────────────────────────────────┘

            This is your alarm system.

   If the light beam is walked through then the piezo
                sounder will switch on.

   ┌─────────────┐                    ┌──────────────┐
   │ Light Beam  │                    │ Piezo Sounder│
   │             │      Process       │              │
   │   Input     │  ⇨            ⇨    │   Output     │
   └─────────────┘                    └──────────────┘

   If you want to change this then.      ↵
                                     click here

   If you want to continue then.        ⇨
                                     click here        (Show)
```

Buttons Changed To Arrow
Icons To Aid Navigation

• users asked for 'friendlier' sounds to be used as the orientation activity is revealed.
New sounds were incorporated.

In Developer 10 the input content for the wire loop was added.

In Developer 11 the input content for the tremble switch was added.

In Developer 12 the output content for the bulb was added.

In Developer 13 the output content for the buzzer was added.

In Developer 14 the output content for the piezo sounder was added.

In Developer 15 the process content for the thyristor was added.
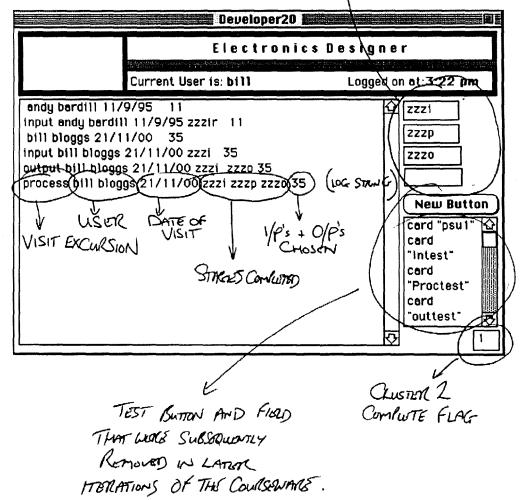
At this point the input, process and output content for cognition cluster 2 was complete.

The data stored on the logger node was sufficient for the system intelligence to

recognise the user, the stages that they had completed and what their last activity was.

The next steps were to enable the system intelligence to apply the user model to the

remaining intelligence outcomes for cluster 2, i.e.personalisation of the orientation

activity, personalised guidance and automatic transfer from cluster 2 to cluster 3 after all

three stages were completed. The log on script in the stack background was further

developed to provide this improved system intelligence and a flag was added to the

logger node to indicate whether all stages had been completed.

PLACE HOLDERS TO HELP
CONSTRUCT/DECODE THE
LOG STRING

Developer20

Electronics Designer

Current User is: bill   Logged on at 3:22 pm

```
andy bardill 11/9/95   11
input andy bardill 11/9/95 zzzir  11
bill bloggs 21/11/00   35
input bill bloggs 21/11/00 zzzi  35
output bill bloggs 21/11/00 zzzi zzzo 35
process bill bloggs 21/11/00 zzzi zzzp zzzo 35
```

zzzi
zzzp
zzzo

(LOG STRING)

New Button

card "psu1"
card "intest"
card "Proctest"
card "outtest"

1

USER
VISIT EXCURSION

DATE OF
VISIT

I/P's + O/P's
CHOSEN

STRING CONVERTED

TEST BUTTON AND FIELD
THAT WERE SUBSEQUENTLY
REMOVED IN LATER
ITERATIONS OF THE COURSEWARE.

CLUSTER 2
COMPLETE FLAG

In Developer 16 the input orientation activity for the micro switch was added.

In Developer 17 the input orientation activity for the reed switch was added.
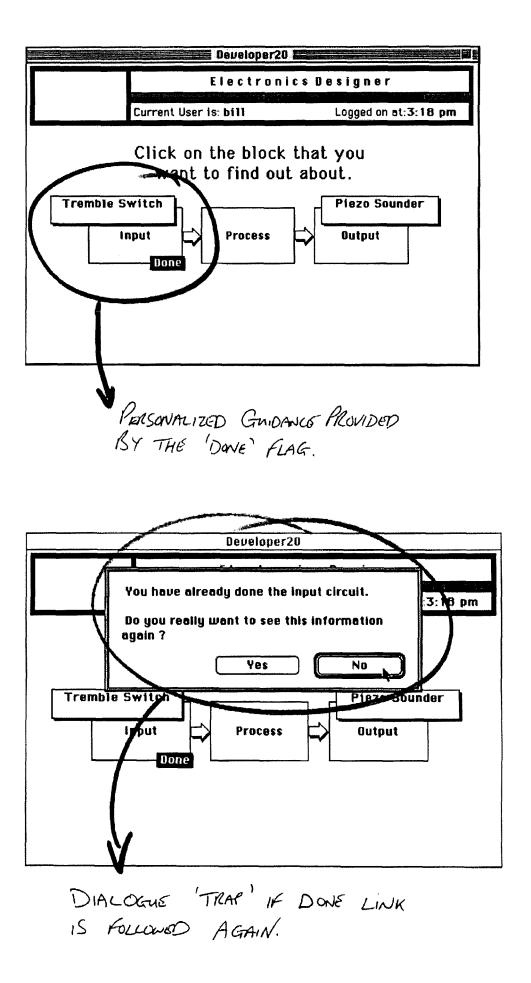
In Developer 18 the input orientation activity for the presure switch was added.

In Developer 19 the input orientation activity for the tremble switch and the light beam was added.

In Developer 20 the process and the three output orientation activities were added. The automatic link to cluster 3, established after completion of all three stages, was initiated. Personalised guidance was incorporated into the main system node. Excursions that had already been followed were given a 'done' flag. If a user still attempts to follow them then a warning dialog is presented and the option to follow the link or not is given. This 'trap' is there to allow legitimate revisits to the excursion materials, whilst attempting to avoid disorientation or pointless wandering.

Developer20

Electronics Designer

Current User is: bill   Logged on at: 3:18 pm

Click on the block that you want to find out about.

Tremble Switch		Piezo Sounder
Input	Process	Output

Done

PERSONALIZED GUIDANCE PROVIDED
BY THE 'DONE' FLAG.

Developer20

You have already done the input circuit.

Do you really want to see this information again ?

Yes   No

3:18 pm

Tremble Switch		Piezo Sounder
Input	Process	Output

Done

DIALOGUE 'TRAP' IF DONE LINK
IS FOLLOWED AGAIN.

Cluster 3

Intelligence income:
User model developed
Users stage completion recorded

Intelligence Outcome:
Personalisation of the orientation activity
Personalisation of the stage node (embelishment)
Personalised guidance
Linking only relevant power supply excursion to
the stage node
Automatic link to relevant setting up and testing node
after excursions are completed
Automatic transfer link from stage 3 to 4

Setting up and testing

Battery excursions

Power Supply, Setiing up and Testing
Stage Node Dynamic content:
Guidance about what to do
Guidance about what has been done

Excn   6Volt

Excn   9Volt

Visit → Log On invoke the user model → Ont → Stage →

Orientation activity
relates to previous
visit activity

Switch excursion

Excn

Automatic transfer after
one comlete visit to the cluster

Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation
Act → Realisation

Fig. 24 Cognition Cluster Three

The user model was now sufficiently detailed, and the process of enabling system intelligence to instantiate intelligence outcomes and gather intelligence income sufficiently established in cluster 1 and 2, to make the development of cluster 3 a relatively straightforward process.
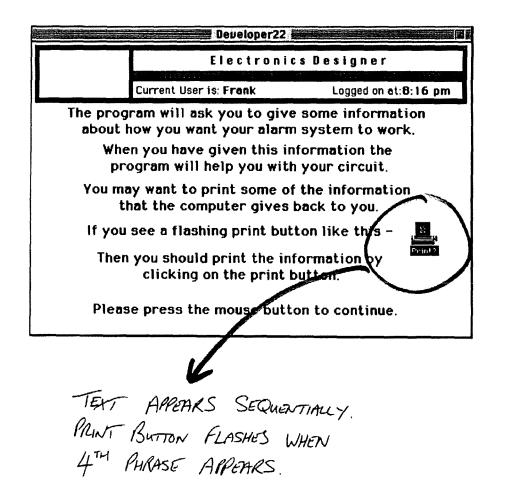
In Developer 21 all of the necessary content for cluster 3 was added and the automatic link to cluster 4, established after completion of both cluster 3 excursions, was initiated.

Under user testing:

• There were still some problems with users not fully understanding how to log off and the importance and process of printing the information given on cards with a flashing print icon. An animated tutorial explaining these generic issues was added to cluster 1 in Developer 22.
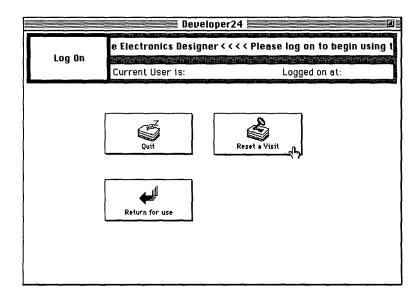
Log off Button Flashes after 1st phrase appears.

Developer22

Electronics Designer

| Current User is: Frank | Logged on at: 8:18 pm |

If you see the 'Log Off' button flashing like this →

then it's time to log off and go and complete the next bit of your circuit.

Note always check to see if you should print the information before you Log Off.

Please press the mouse button to continue.

Text Appears Sequentially

```
================ Developer22 ================ [■]

┌──────────┬──────────────────────────────────────┐
│          │        Electronics Designer          │
│          ├──────────────────────────────────────┤
│          │ Current User is: Frank    Logged on at:8:16 pm │
└──────────┴──────────────────────────────────────┘
    The program will ask you to give some information
     about how you want your alarm system to work.

       When you have given this information the
         program will help you with your circuit.

     You may want to print some of the information
        that the computer gives back to you.

   If you see a flashing print button like this -       [Print?]

     Then you should print the information by
          clicking on the print button.

     Please press the mouse button to continue.
```

TEXT APPEARS SEQUENTIALLY.
PRINT BUTTON FLASHES WHEN
4TH PHRASE APPEARS.

• As the desktop and the menu bar were both hidden to prevent users from accidently

exiting or losing the courseware it now became apparent that teachers might not have

known how to quit the courseware! This led to the development of a teachers control

node in Developer 22 accessed by logging on as 'hyperTeacher'. This node initially

simpy contained a button allowing teachers to quit.

• The benefit of developing this teachers' control node began to emerge as further user

testing occured. The automatic links established between clusters after the cluster

content has been completed, effectively means that content from that previous cluster is

no longer accessible. This would not normally be problematic unless a printer fault had

occured during the final cluster excursion or a system failure or crash. Owing to the

unpredictability of such events a facility to remove a visit from any given user model was provided from the teachers' control node in Developer 23.

• A button to seamlessly return the courseware to general use was added to the teachers' control node in Developer 24.

Developer24

> **Electronics Designer < < < < Please log on to begin using th**
>
> Log On
>
> **Enter the full name of the pupil**
>
> andy bardill
>
> [OK]   [Cancel]
>
> Quit   Reset a Visit
>
> Return for use

Developer24

> Log On   **This is the last visit of name**
>
> *** andy bardill 10:20 pm 24/9/95 ***
>
> **Do you want to erase this visit?**
>
> [No]   [Yes]
>
> Return for use

Developer24

> **Electronics Designer < < < < Please log on to begin using th**
>
> Log On
>
> **Delete another visit?**
>
> [Yes]   [No]
>
> Quit   Reset a Visit
>
> Return for use
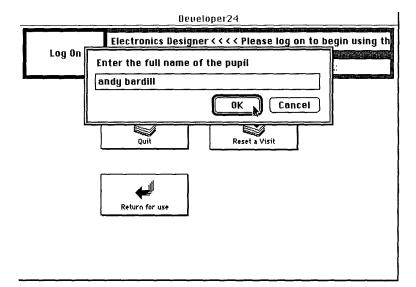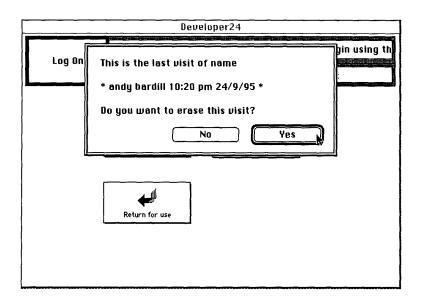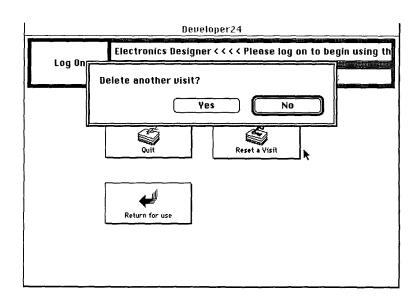
Developer 24 was used for the user test with the group of PGCE students as described

in section 2 of this chapter. A number of issues that needed to be addressed were

identified during this test. It is evident from the nature of these issues that some of them

would be unlikely to come to light in an individual user testing scenario.

• When the courseware was installed on a number of publicly accessible machines for

the duration of the test it became evident that users not associated with the trial were

using it. With a conventional piece of software this would not be problematic, but as this

courseware relies upon the collection of user models to support its intelligence it is

imperative that those user models are not corrupted. Furthermore, if the user models are

to be extracted for subsequent analysis after a trial then the integrity of the data must be

ensured. To overcome the potential problems caused by the natural curiosity of users

who encounter a new icon to double - click it, an access password was added to the

front end of the courseware in developer 25. This prevented unauthorised users from

accessing the courseware.

In Developer 26
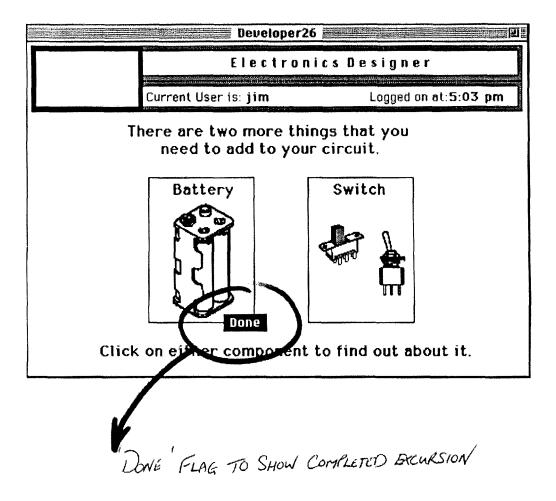
• Some users were not immediately aware that the 'Log-On button was in fact a button.
A new more obvious icon was added.

New Log on Button Icon.

• Some users were confused by the battery and switch excursions as they were not

initially aware that there were two separate links from the main node. This lead some to

continuously loop around one excursion as the conditional link to the activity node is

not established until both separate excursions have been followed. 'Done' flags were

added to the main node to guide users around the two excursions.

"DONE' FLAG TO SHOW COMPLETED EXCURSION

Cluster 4's main node content was established and the links to its associated excursions were added.

During the PGCE trial the courseware was installed on 12 individual machines, some of which were used by 3 or 4 users. It became apparent that the path data, a record of the nodes visited by a user stored as text in a background field, was rapidly exceeding the 30 000 character limit for all hypercard objects. This diffuclty was overcome by modifying the 'log on' routine. When a first time user logs in a new node is created for them and the path data for their own user model is stored on that unique node. The user model is now effectively split between the 'logger card' and the 'path card'.

UNIQUE PATH CARD FOR EACH USER.

```
┌─────────────────────────────────────────────────────────────┐
│                        Developer26                      ▣  ▣ │
├───────────┬───────────────────────────────────────────────┤
│   ┌───┐   │ Please log on to begin using the Electronics Designer < < < │
│   │ ╱ │   ├───────────────────────────────────────────────┤
│   └───┘   │ Current User is:              Logged on at:     │
│   Log On  │                                                 │
├───────────┴─────────────────────────────────────────────┬──┤
│ andy bardill 2:15 am 17/11/95                            │⇧│
│ card "Intro2"                                            │  │
│ card "secondVis"                                         │  │
│ card "secondVis"                                         │  │
│ card "secondVis2"                                        │  │
│ card "Switchinfo1"                                       │  │
│ card "Switchinfo2"                                       │  │
│ card "switchinfo3"                                       │  │
│ card "switchinfo5"                                       │  │
│ card "switchinfo13"                                      │  │
│ card "First"                                             │  │
│ andy bardill logged of at 2:18 am                        │  │
│ andy bardill 2:18 am 17/11/95                            │  │
│ card "intro1"                                            │  │
│ card "stest1m"                                           │  │
│ card "stest2m"                                           │⇩│
└───────────────────────────────────────────────────────┴──┘
```

PATH DATA FOR ONE VISIT

LOGGED CARD DATA FOR THIS VISIT

```
┌─────────────────────────────────────────────────────────────┐
│                        Developer26                      ▣  ▣ │
├───────────┬───────────────────────────────────────────────┤
│   ┌───┐   │ o begin using the Electronics Designer < < < < Please log on │
│   │ ╱ │   ├───────────────────────────────────────────────┤
│   └───┘   │ Current User is:              Logged on at:     │
│   Log On  │                                                 │
├───────────┴──────────────────────────────────┬──┬──────────┤
│ andy bardill 16/11/95  11                     │⇧│┌──┐┌──┐   │
│ input andy bardill 17/11/95 zzzim  11         │  ││  ││  │   │
│ output andy bardill 17/11/95 zzzi zzzo 11     │  │└──┘└──┘   │
│ input andy bardill 17/11/95 zzzi zzzo 13      │  │┌──┐       │
│ harold thimbleby 17/11/95   33                │  ││ 0│ tsp   │
│ Jim McDonnell 18/11/95   35                   │  │└──┘      ⇧│
│ process Jim McDonnell 18/11/95 zzzp 35        │  │┌─────────┐│
│ input Jim McDonnell 18/11/95 zzzi zzzp 35     │  ││         ││
│ output Jim McDonnell 18/11/95 zzzi zzzp zzzo 35│  ││         ││
│ process andy bardill 4/1/96 zzzi zzzp zzzo 13 │  ││         ││
│ zzzbatt andy bardill 4/1/96 zzzi zzzp zzzo 13 │  ││         ││
│ zzzbatt Andy bardill 4/1/96 zzzi zzzp zzzo 13 │  ││         ││
│ zzzbatt andy bardill 4/1/96 zzzi zzzp zzzo 13 │  ││         ││
│ zzzbatt andy bardill 4/1/96 zzzi zzzp zzzo 13 │  ││         ││
│ zzzbatt jim mcdonnell 5/12/00 zzzi zzzp zzzo 35│⇩││         ⇩│
└────────────────────────────────────────────┴──┴──────────┘
```

Output always on

Intelligence income:
User model developed

Intelligence Outcome:
Personalisation of the orientation activity
Personalisation of the stage node (embelishment)
Personalised guidance
Linking only relevant excursions to the sub-nodes available
Formation of nodes and links within excursions.

Excn — Act → Rectification
Rectification
Act → Rectification
Rectification
Act → Rectification

To 18 possible circuit types

Fault finding

Excn

To 18 possible circuit types

Extension Information
Stage node Dynamic content:
Targetted at the sub-nodes
accessible from this point and
dependent upon their focus

Output never on

Visit →

Log On
invoke the
user model

Ont

Stage

Excn

Rectification
Rectification
Rectification
Rectification
Excn — Act → Rectification

Orientation activity relates to previous
visit activity from cluster 3.
Only ever1 instantiation of the
orientation activity on the first visit.
Subsequent visits lead straight to the stage node

Excn

Content and strucure
dependent upon task focus.
Proportion of links and nodes can
be intelligence outcome (automatic)
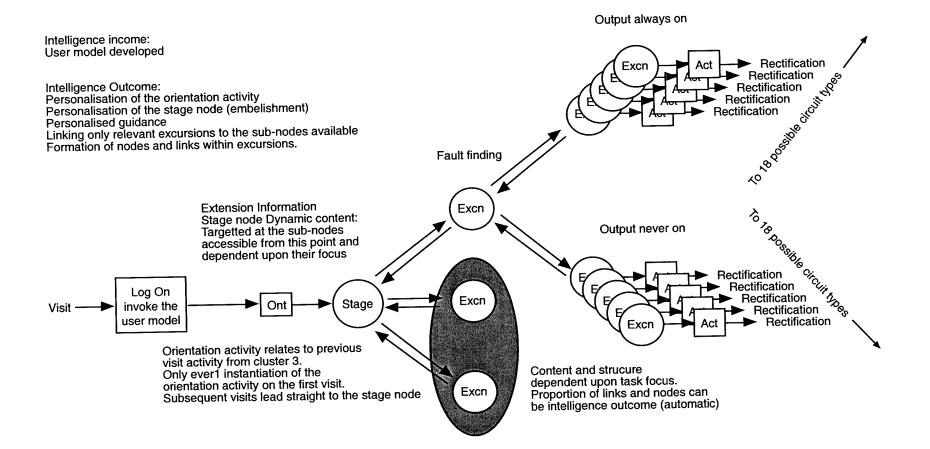
Fig. 25 Cognition Cluster Four.

The link to cluster 4 and its associated excursion links had been established in developer 26. In developer 27 the fault finding excursions were added for the 18 possible circuits in the two possible conditions.
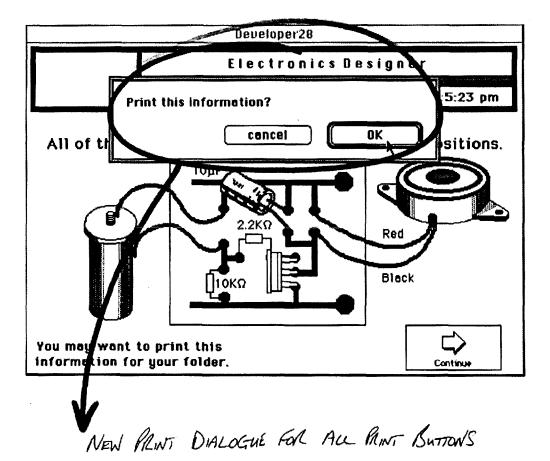
A number of further issues arrising from the PGCE trial were addressed in Developer 28:

• Users who made impatient or extraneous mouse clicks were able to 'mouse ahead', skipping content as a result of the stored clicks, on some nodes. This had been noted on earlier user tests but the issue became far clearer when the courseware was used in this more naturalistic setting. For the first time the courseware was being used to complete a task and the need to press-on caused more users to experience this problem. Extra mouse clicks were trapped by modifying the stack script to trap the extra clicks given whilst any script is running.

• Some users were unsure about the state of their answers in the orientation activities as they did not necessarily associate forward progress through the activity with a correct response. Simple high and low buzzes were the audio response used until this point, so to overcome the difficulty voice recordings were added to the activity nodes to make it clear whether the question had been answered correctly or not.

• For the first time users need to gain hard copy from the printable nodes. It became apparent that, as users were not required to commit to the printing through a normal dialogue box, they often pressed the 'print' icon more than once as they were not sure whether it had worked or not. This difficulty was overcome by adding print feedback via a dialogue box and an audio flag.

NEW PRINT DIALOGUE FOR ALL PRINT BUTTONS
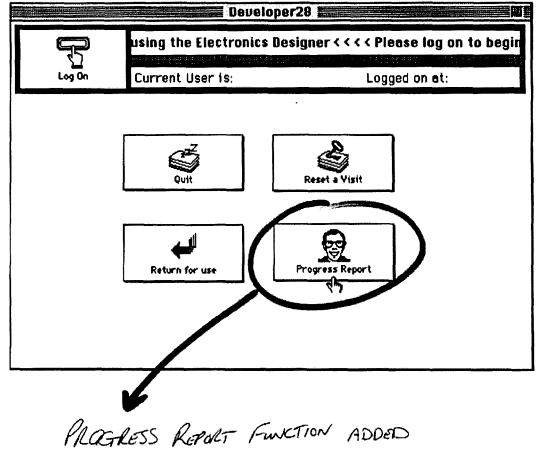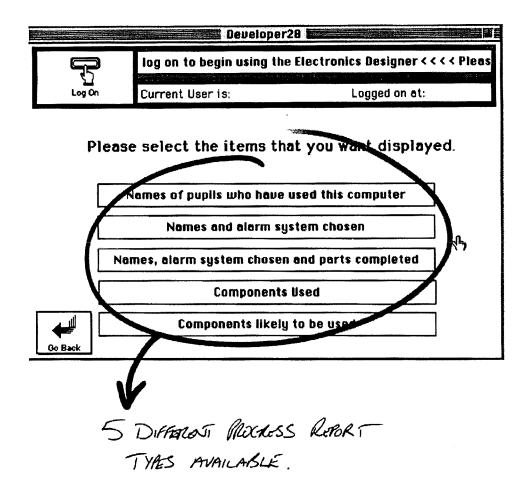
Developer 28 was the version presented to the teacher who would administer the final

user testing scenario in the design and development phase. This was to be in the

completely naturalistic setting of a normal school Design and Technology workshop

where the courseware would be integrated into the completion of a project. When this

teacher was shown the 'hyperTeacher' card and had the underlying system intelligence

and user model explained to them, they observed that the user model data stored on the

'logger' card could be used to tell them how many components they would need to

supply for their group to complete the project! This was timely observation as it was

realised that, as a consequence of using this courseware, teachers might become

detached from the progress of events as their pupils became ever more autonomous. To

overcome this difficlty a series of progress reports were made available from the

'hyperTeacher' card. These report routines extract the data from the 'logger' card and

present it in a number of formats; a development that was welcomed by the participating

teacher.

PROGRESS REPORT FUNCTION ADDED
TO HYPERTEACHER PAGE.

```
┌──────────────────────────────────────────────────────────────────┐
│ ▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓  Developer28  ▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓▓  ▓▓│
│ ┌───────────┬──────────────────────────────────────────────────┐ │
│ │    ╤      │ log on to begin using the Electronics Designer < < < < Pleas │
│ │   ┌┘      ├──────────────────────────────────────────────────┤ │
│ │  Log On   │ Current User is:              Logged on at:       │ │
│ └───────────┴──────────────────────────────────────────────────┘ │
```

Please select the items that you want displayed.

```
        ┌──────────────────────────────────────────────┐
        │   Names of pupils who have used this computer  │
        └──────────────────────────────────────────────┘
        ┌──────────────────────────────────────────────┐
        │          Names and alarm system chosen         │
        └──────────────────────────────────────────────┘
        ┌──────────────────────────────────────────────┐
        │  Names, alarm system chosen and parts completed │
        └──────────────────────────────────────────────┘
        ┌──────────────────────────────────────────────┐
        │                 Components Used                │
 ┌────┐ └──────────────────────────────────────────────┘
 │ ⬅  │ ┌──────────────────────────────────────────────┐
 │Go Back│ │          Components likely to be used        │
 └────┘ └──────────────────────────────────────────────┘
```

5 DIFFERENT PROGRESS REPORT TYPES AVAILABLE.

ElectronicsDesigner 1.0 was born. It was awarded a new, colour desk top icon and copied ready for the final user test in the design and development phase.

This final user test in a fully naturalistic setting provided the opportunity to finally test the integrity of the courseware content and operation with a representative sample of the target end users. The major issue to arise from this user test being the increasing importance of the printed material users gained from the courseware in the completion of their tasks. The teacher administering the trial reported a number of problems with

the printers they were using, the majority of which were simply down to the printer not

being switched on and tested at the start of the lesson. A printer test facility was added

to the 'hyperTeacher' card to enable a teacher to quickly test a connected printer when

using the courseware.

This final stage completed the courseware development with respect to end users.

However, work continued throughout the school summer holiday period to build a suite

of complimentary data extraction and analysis tools. It was essential that these tools

were built prior to entering the trail and evaluation phase of this current research as it

was necessary to establish that the user model data collected could be subsequently

extracted from the courseware in a form that could be analysed. This resulted in the

development of 'dataExtract', which is described further in section 4 of this chapter.

ElectronicsDesigner 1.01 was used for both stages of the trial and evaluation phase in

all but one of the trial schools of this current research. In one trial school, one

participating teacher continued to report printing problems. The requested solution was

an automatic printer test facility when the courseware is booted up. This functionality

was added to electronicsDesigner 1.02. On boot-up the courseware opens a printer test

routine that results in the printout of a courseware access code that is unique to the

session. The courseware cannot be used until the code is entered, thereby ensuring the

correct functioning of the printer. This is only a satisfactory solution when each

participating computer is connected to an individual personal printer. It would be

unmanageable in a networked printer situation and remains unresolved in the

courseware prototype.

References:

Apple Computer Inc. (1989) HyperCard Stack Design Guidelines - Addison-Wesley:Wokingham, England

Coulouris. G. and Thimbleby. H. (1992) HyperProgramming: Building Interactive Programs with HyperCard - Addison-Wesley:Wokingham, England

comp.sys.mac.hypercard - USENET newsgroup

Chapter 3 - Operationalising the Research

Section 4 - Developing the Research Instruments

In developing the research instruments for the trial and evaluation phase of this current research, it was necessary to adopt approaches that could support the developed methodology; a crucial aspect of this methodology being the naturalness of the setting in the trial phases. It is only in a truly naturalistic setting that the efficacy and associated consequences of using this courseware can be fully illuminated for others and, hence, the relateability of this current research is reliant upon it. The importance of this factor precluded the use of simple observation techniques in either participant or non-participant mode.

Participant observation, by the developer or researcher, would disbar all notions of illuminating the performance of the courseware in a range of learning milieu. The interpretation of the set task and the construction of the learning situation would be particular to that participant and, hence, unitary. Such a situation would lead to singular outcomes and reduced potential for relateability. Hence, the teacher must be someone other than the researcher and a number of teachers must participate.

Non-participant observation would overcome these difficulties, but the objectivity of the observed situation might be called into question. The very presence of the observer will degrade the naturalness of the trial situation. There are likely to be user reactions relating to issues such as being 'on-show' and performing to expectations. The availability of the observer would provide a natural point for the provision of feedback by participating teachers at the end of each observation session. However, that feedback would be being given in the heat of the moment without the opportunity for the teacher to reflect on those events. Immediate feedback would, therefore, be likely to have an overbearing concentration on organisational, singular considerations, whereas feedback given in the light of reflection is likely to take a broader more balanced view of the learning milieu as a whole. There may be a tendency for technical problems encountered to be directed to the observer, particularly if the observer is known to be the developer of the courseware. If responded to this would provide an unnatural level of support for the courseware implementation; if ignored then potentially some feelings of dissatisfaction with participating in the trial would result. Furthermore, the physical position of the observer would be problematic; where would they be best positioned to 'observe'? Undertaking an observation at macro level would be difficult to achieve. Design and Technology facilities are rarely arranged in a single closed room. Teachers and pupils are often required to move between adjoining rooms, or sectioned off areas within the rooms in order to access the necessary facilities to complete a project. This issue is particularly important when computers are introduced into the range of facilities required as they are most often sited in clean, quiet areas in either a central location in the department or in a sectioned off portion of the workshop. Maintaining the same level of observation, and hence objectivity, in the variety of learning milieu demanded by the methodology would require the observer to literally follow the teacher from room to room and area to area, or the deployment of a team of observers scattered throughout the department - a situation that at best would bring about a mild curiosity in the

participating pupils and at worst would severely degrade the naturalness of the trial

situation. Perhaps then the observer might undertake a micro level observation and

concentrate upon the computer area itself? Again the naturalness of the situation would

be potentially degraded. The simple presence of an adult person in the computer area

may change the behaviour of the participating pupils and affect their interaction with,

and opinions of, the courseware.

In finally rejecting simple observation as an appropriate research method for the trial

and evaluation phase of this current research it is useful to return to the words of Parlett

and Hamilton in describing the aims of their illuminative methodology,

> *It aims to discover and document what it is like to be participating in the*
> *scheme, whether as a teacher or pupil; and in addition, to discern and*
> *discuss the innovation's most significant features, recurring concomitants*
> *and critical processes.*
>
> (Parlett and Hamilton 1972 P.9)

What emerges from this discussion is that simple observation would perhaps be an

inelegant, 'knee-jerk' response to the trial of new courseware, and that it would be

difficult to meet the demands of this illuminative methodological aim. However, Parlett

and Hamilton's 'Observe, Inquire, Explain' process model has been incorporated into

the methodology for this current research, so how is the 'observation' element to be

completed without the presence of an observer? Again the centrality of the teacher in

these learning milieux becomes significant. It has already been identified, discussed and

incorporated into the courseware development model in the design and production

phase of this current research. The teachers themselves could be used as participant

observers, but requiring them to follow a particular observation schedule, apart from

their normal reflective practice, could again compromise the naturalness of the trial

situation. However, it is their reflective accounts that will provide the central themes to

the illuminative discoveries. It is evident that the Parlett and Hamilton process model is

applicable if teachers are used as 'participant observers', but that the research

instruments used to document these observations must be carefully constructed to

preserve the naturalistic properties of the trial scenario. Hence, teachers can be used as

non-systematised, participant observers who collect observation data by the construction

of their reflective accounts and that these reflective accounts can be elicited, focused

and documented via semi-structured interviews. The need for the interview to have

structure, and the tightness or looseness of that structure, relates to these key themes of

eliciting and focusing; too tight a structure restricting the extent of the reflective account

that can be elicited; too loose a structure causing a lack of focus and poor illumination

of all the major issues of the reflective account.

With this 'observation' data collected the 'enquire further' phase can be begun by an

analysis of the observers' reflective accounts, structured by an evaluative interplay with

the specification criteria. However, this enquiry could not reasonably be expected to be

complete as it focuses only on qualitative data concerned with the perceptions of the

participating teacher. For a thorough enquiry to be enabled this qualitative data must be

triangulated against quantitative data that can illuminate aspects concerned with the

courseware performance and how it was used by pupils. Hence, further data must be

collected to represent all parties in the learning milieu and strategies must be devised to

enable these data to contribute effectively to a coherent explanation.

So, the reflective account of the teacher, collected by semi-structured interview, becomes the initial component of the enquiry. Data extracted from the individual courseware user models can be used to illuminate the operational deployment of the courseware (how it was actually used, rather than perceived to be used, by the teachers and pupils). Hence, 'brightness' and 'contrast' functions can be added to the illuminative evaluation process by triangulating the qualitative reflective accounts against the quantitative data gained from the courseware user models. The outcomes resulting from this illuminative evaluation process would be a range of individual school based case studies serving to illuminate the effects of introducing the courseware in to a range of learning milieux. The following process indicates how these two research instruments can be used to provide the explanatory outcomes from the Parlett and Hamilton process model:

• The semi-structured interview transcript provides the researcher with the major issues from the trial.
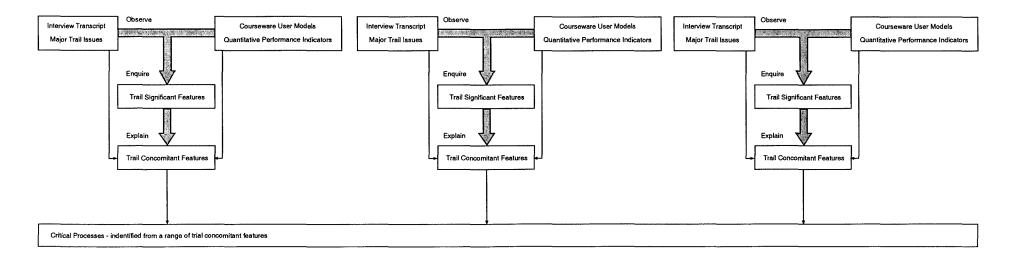
• The data gained from the courseware user models provides the researcher with quantitative indicators about a range of courseware performance and interaction issues.

• The two data sets enable the construction of a list of the significant features of the trial.

• Analysis of this list of significant features, guided by the two triangulating data sets, can seek to identify the concomitant relationships between these features.

• Analysis of the range of concomitant features from across the trials can seek to identify the critical processes that have been operating within and across the trials.

Hence, the relatable outcomes from this illuminative evaluation process are the critical processes identified and these critical processes can be used to inform subsequent iterations and instantiations of courseware using the development paradigm.

Fig. 34 The Use of the Research Instruments

| Interview Transcript | Observe | | Courseware User Models |
| Major Trail Issues | | | Quantitative Performance Indicators |

Enquire

Trail Significant Features

Explain

Trail Concomitant Features

| Interview Transcript | Observe | | Courseware User Models |
| Major Trail Issues | | | Quantitative Performance Indicators |

Enquire

Trail Significant Features

Explain

Trail Concomitant Features

| Interview Transcript | Observe | | Courseware User Models |
| Major Trail Issues | | | Quantitative Performance Indicators |

Enquire

Trail Significant Features

Explain

Trail Concomitant Features

Critical Processes - indentified from a range of trial concomitant features

The two requisite interview schedules were developed in accordance with the project

methodology; the first schedule having a broad focus on organisational issues associated

with the courseware trial, the second schedule having a slightly tighter focus on the

educational issues associated with the courseware trial. Both question sets were devised

so that they could relate back to the courseware specification to illuminate its feed-

through into the learning milieu. They also sought to illuminate other key aspects of the

milieu, e.g. the task type that pupils were engaged in, the previous experience of the

teacher etc., to enable any significant features brought about by the use of the

courseware to be included in the construction of the case study account. The data

collected by interview would give a qualitative account of the effects of introducing the

courseware into the learning milieu. Both interview schedules are included in appendix

2.1

A second research instrument was developed to extract the user model data from the

used courseware. This would enable the researcher to gain a completely quantitative

insight into how the courseware had been used by the pupils. The resultant data sets

would enable robust triangulation between the qualitative teachers' accounts and this

quantitative user model data. This instrument took the form of a hyperCard stack

developed by this researcher and called 'dataExtract'. An example of it with some

locally constructed data is available on the included CD-ROM with screen-shots

included in appendix 2.2 A variety of tools were built into the dataExtract stack to

enable the researcher to 'sift' through the data to gain an initial insight into how the

courseware had been used. These include the ability to view the group list of pupils

using the courseware and then to view decoded aspects of individuals user model data

by simply clicking on a pupil name. A further set of tools enables the researcher to

anonymise and variously organise the user model data in the form of tab delimited text

files. These files can then be imported into a spread-sheet package, e.g. MicroSoft

Excel, for subsequent quantitative analysis.

References:

Parlett. M. and Hamilton. D. (1972) Evaluation as Illumination: A New Approach to

the Study of Innovatory Programs - Occasional Paper: Centre for Research in the

Educational Sciences: University of Edinburgh

Chapter 3 - Operationalising the Research

Section 5 - Analytical Method

Interviews

The interviews were conducted, using the appropriate interview schedule, as soon after the trial as was opportune. The interviews were tape recorded and subsequently transcribed by the researcher. The interview transcripts were then loosely tagged using criteria from the courseware specification and additional items relating to the teachers previous experience and the task type that the courseware had been used to support. This tagging process enabled blocks of text from the interview transcripts to be rearranged into areas that related to the tags. The list of tags used with both interview schedules was:

EE - Experience in Electronics

Used to identify blocks of text relating to the participating teacher's previous teaching experience with electronics in their Design and Technology teaching and their own perceptions of their capability to teach it.

TT - Previous Task Types

Used to identify blocks of text relating to the type of tasks that they had previously undertaken with pupils and any indications of the task type that they had used the courseware to support (referenced against the taxonomy of task types).

EC - Experience in using educational software

Used to identify blocks of text relating to the participating teachers use of educational software, in its broadest sense, to support their teaching in Design and Technology. This tag was not specifically related to electronics and sought to gain an insight into the participating teachers attitudes to using computers to support their everyday teaching.

S1,2 - Computer Numbers and Performance

Taken from criteria 1 and 2 of the courseware specification and used to identify blocks of text relating to the situational features of the trial. These features included the number of computers used to support the courseware, where they were situated, how pupils gained access to them and any issues that were associated with supporting the courseware with the resources that were available for the trial.

S3,4,5 - Individual learning support

Taken from criteria 3, 4 and 5 of the courseware specification and used to identify blocks of text relating to any issues regarding the individual learning support given to pupils by the courseware during the trial.

S6 - Task type C support

Taken from criterion 6 of the courseware specification and used to identify blocks of text relating to any issues relating to the ability of the courseware to support a type C task or issues associated with undertaking a type C task in that particular learning milieu.

S7a - Pupil autonomy, motivation, work rate, success, empowerment

Taken from criterion 7a of the courseware specification and used to identify blocks of text relating to any issues associated with the pupils' 'practicality ethic' and the levels of compliance with it when using the courseware.

S7b - Teacher control support empowerment

Taken from criterion 7b of the courseware specification and used to identify blocks of text relating to any issues associated with the teachers' 'practicality ethic' and the levels of compliance with it when using the courseware.

S8 - Other applications

Taken from criterion 8 of the courseware specification and used to identify blocks of text relating to the teachers perceptions of how courseware of this type might relate to other subject areas in their teaching.

The rearranged transcripts enabled a reflective account to be built up that was organised into these general areas and that removed the questions and probes from the transcripts, so enabling an objective analysis to be undertaken. This modified transcript was used to identify and list the major issues from the trial in relationship to the courseware specification criteria and the teacher's personal situation.

Courseware User Models

The data from the courseware user models was extracted from the used courseware using the dataExtract tools developed by this researcher. The data was inserted into a Microsoft Excel spread sheet for subsequent analysis and chart production. A range of quantitative indicators were produced from this data and this set of indicators were expanded as themes emerged during the analysis phase. The need for flexibility in data analysis tools when conducting illuminative evaluation studies is implicit. Broad data needs to be collected so that they will be sufficient to provide triangulation points for the qualitative issues arising from the trial. The data analysis tools must have the

capability to respond to these quantitative issues as the themes and features emerge. The following quantitative indicators and the methods for their interpretations were used:

Level of Deviant Courseware Interaction

The level of deviant courseware interaction was arrived at by :

• Establishing the number of deviant interactions under the following categories that were observed in the user model data: Miss-spelled name; Premature Switch-off; Spurious Log-in; Non-group Log-ins; incorrect name syntax.

• Establishing the number of pupils that these deviant interactions were attributable to (some pupils undertook more than one deviant interaction)

• Dividing the number of deviant interactions by the number of pupils that these interactions could be attributed to give a deviancy rate.

• Dividing the deviancy rate by the number of pupils undertaking deviant interactions to gain an average deviance per deviant pupil and then multiplying this by the total number of pupils using the courseware to give the deviancy level for the trial.
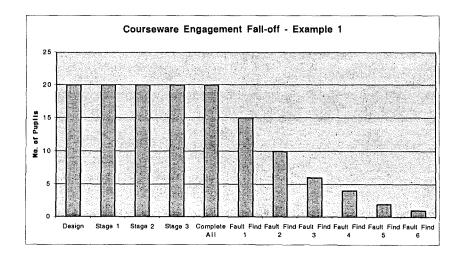
The deviancy level for the trial then gave a single number that was independent of the group size and that could be used as a relative indicator of the levels of deviant courseware interaction across the trials.

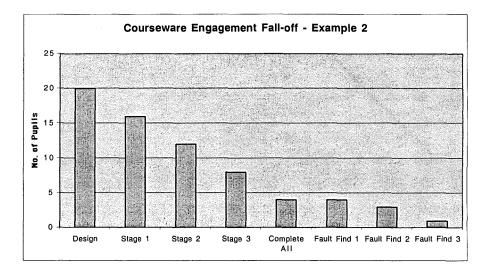**Courseware engagement and completion fall off**

Data from the user models was used to establish how many pupils had completed each section of the courseware to indicate percentage completion rates and overall levels of courseware usage. In order that these profiles could be used to gain comparable quantitative indicators, and trial averages, the group sizes were standardised to twenty pupils by adjusting the frequency of responses by the appropriate proportion. Two line charts were produced for each trial group. The first relating to the entire courseware usage by the trial group. This was termed as 'courseware engagement' and gave an indicator of the levels of courseware use and where the significant drop-out points were. Some examples of possible courseware engagement profiles are shown below:

Example 1 (below) shows a courseware engagement profile that indicates a high performance in terms of pupil engagement with the courseware. The first portion of the profile, from 'design' to 'complete all', shows a rectangular distribution, which represents the desired 100% completion rate of the compulsory elements of the courseware. The second portion of the profile, the fault finding stages, shows a fall-off. This indicates the levels of interaction with the fault finding domain necessary to mkae the completed circuits functional.

Fig. 35

Example 2 (below) shows a courseware engagement profile that indicates a lower level

of performance in terms of pupil engagement with the courseware. The first portion of

the profile, from 'design' to 'complete all', shows a fall-off that indicates pupil opt-out

or non completion of the compulsory elements of the courseware. The second portion of

the profile, the fault finding stages, indicates some engagement with the fault finding

domain, but with levels that are reduced to levels that are commensurate with the

reduction in numbers of pupils completing the courseware.

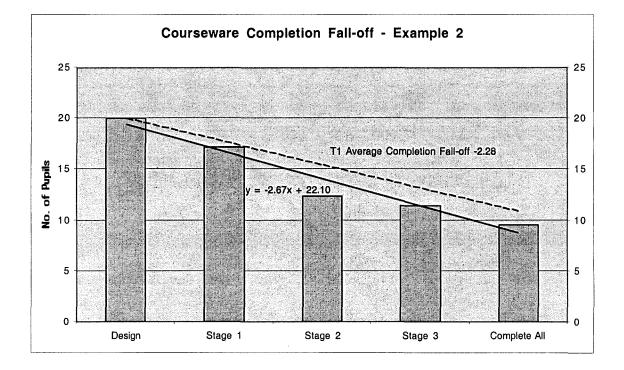**Courseware Engagement Fall-off - Example 2**

Fig. 36

These courseware engagement profiles lend insight into the overall levels of pupil

engagement with the courseware through the trial period. However, they do not provide

a quantitative indicator of relative performance. This was achieved by the second

profile, termed as 'courseware completion fall-off'. These profiles concentrate on the

compulsory elements of the courseware from 'design' to 'complete all'. A trend-line

was added to these profiles to give an indication of courseware performance, where

steeper gradients of thetrend-line indicate falling levels of courseware performance. By

using data from across the trials it was also possible to formulate a trial average for trial

1 and to use this average as an indicator of relative performance. It was also useful to

include a trend-line for trial 1 on the profiles for teachers participating in trial 2. This

gave an indication of relative performance against the trial 1 average and also in relation

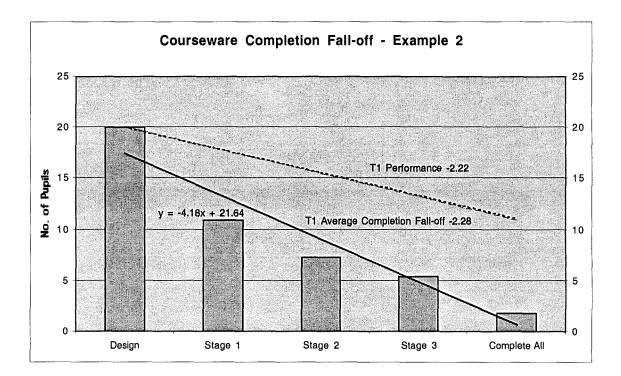to their own group performance in trial 1.

Example 1 shows a courseware completion fall-off profile from trial 1. The profile

indicates a performance that is slightly below average for trial 1.

Courseware Completion Fall-off - Example 2

T1 Average Completion Fall-off -2.28

$y = -2.67x + 22.10$

No. of Pupils (y-axis, 0 to 25)

Design   Stage 1   Stage 2   Stage 3   Complete All

Fig. 37

Example 2 shows a courseware completion fall-off profile from trial 2. The profile

indicates a performance that was slightly better than average in trial 1, but one that has

got considerably worse during trial 2.

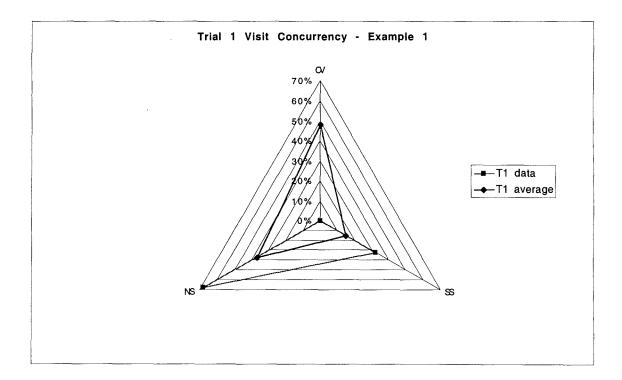**Courseware Completion Fall-off - Example 2**

Fig. 38

The overall visit concurrency profile

Data was extracted from the user models relating to the visit concurrency exhibited by

pupils during the trial for the first 4 intervals between the five compulsory stages. Part

of the courseware design intent is that pupils undertake practical activity in between

their visits to the courseware. If pupils logged in again in the five minute period

following their last visit then this was seen to be courseware use in the same time period

and was termed as a concurrent visit (CV). If pupils logged in again after five minutes

had elapsed, but before sixty minutes had elapsed, then this was seen to be courseware

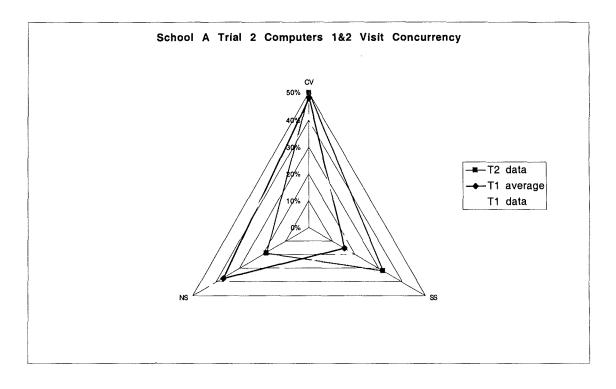use in the same lesson period and was termed as a same session visit (SS). If pupils

logged in again at a point that was over sixty minutes from their last log in then this was seen to be courseware use in a new lesson and was termed as a new session visit (NS). This data was presented as a 'radar' chart to give a clear visual indication of the make-up of the profile from its three components. By comparing data from across trial 1 it was possible to overlay a profile relating to the average distribution of these components across trial 1. This enabled a comparison to be made with the trial 1 average. The trial 2 profiles for visit concurrency also had this trial 1 average overlay, but also had a trial 1 performance overlay. This enables a comparison to be made against the trial 1 average and the teacher's group performance in trial 1.

Example 1 shows a visit concurrency profile from trial 1 that has a good level of congruence with the courseware design intent. There are no CVs evident. There is a predominance of NS visits, with a subordinate level of SS visits, indicating that pupils were engaged in other activities between courseware visits.

Fig. 39

The second example shows a visit concurrency profile from trial 2. This profile shows a

trial 1 profile that is close to average. However, the profile for trial 2 show an increase

in both CVs and SS visits, which indicate a loss of congruence of this profile with the

courseware design intent. Such a loss of congruence would indicate that a concomitance

with another significant feature from the trial, to explain this shift, should be sought.

Fig. 40

Visit Concurrency by Cluster

This visit concurrency data was then subdivided to give a profile of the relative levels of

CV, SS and NS visits in the cluster intervals. These five intervals were grouped into

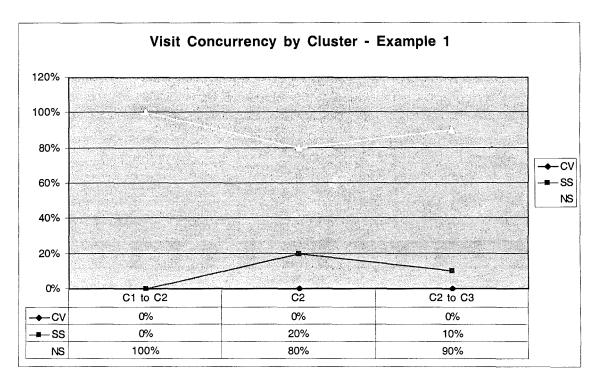three components that related to the project progression:

• C1 to C2 - to show the levels of the three components between designing the system,

logging off to make the printed circuit board (PCB) and then logging back in again to

find out about the circuitry to complete the three stages.

• C2 - to show the levels of the three components whilst pupils were completing the minimum three visits to cluster 2.

• C2 to C3 - to show the levels of the three components when pupils had completed their last cluster 2 visit and made the cluster transition to go on and find out about the battery and switch connections.

This subdivision and grouping of the CV, SS and NS visit data enabled a profile to be constructed that indicated where the individual components were predominant, the levels of congruence with the courseware design intent and, in some cases, confirmed strategies that teachers had invoked to enable courseware completion.

Example 1 shows a visit concurrency by cluster profile that exhibits high levels of congruence with the courseware design intent. There are no CVs evident. There is a predominance of NS visits, 100% in the C1 to C2 transition, and a slight increase in SS visits during C2 as the 'work chunks' are relatively small.
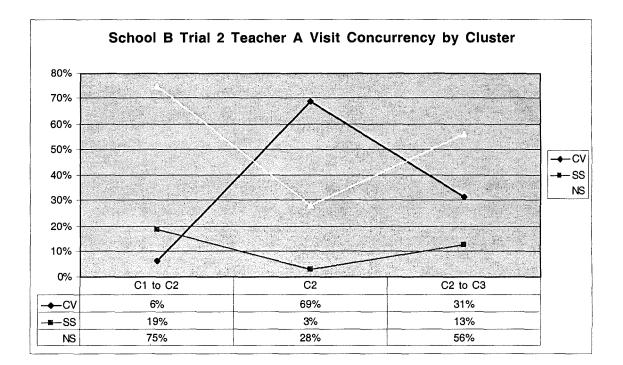

Visit Concurrency by Cluster - Example 1

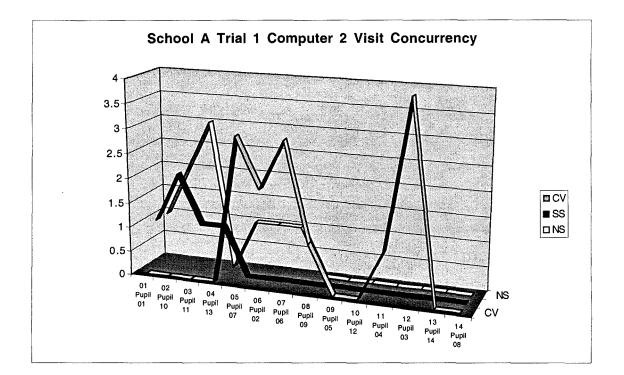|	C1 to C2	C2	C2 to C3
CV	0%	0%	0%
SS	0%	20%	10%
NS	100%	80%	90%

Fig. 41

The second example shows a profile that has a high level of congruence with the courseware design intent in the C1 to C2 transition. There is a predominance of NS visits when pupils should be making their PCBs. There is a notable fall in congruence in the C2 phase, which indicates a large increase in CVs during C2, and a trend back towards congruence in the C2 to C3 transition phase. This would indicate that a concomitant feature from the trial should be sought to explain these trends (in this case it was a teacher invoked strategy to encourage the pupils to gain all of the information for the major electronics construction in a single 'chunk').

School B Trial 2 Teacher A Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
CV	6%	69%	31%
SS	19%	3%	13%
NS	75%	28%	56%

Fig. 42

The Visit Concurrency by Pupil Log-in and Courseware Completion by Log-in Order

Data was extracted from the user models to indicate the levels of CV, SS and NS visits in relation to each pupil and was presented in sequence by the order in which the pupils made their first log-in to the computer, i.e. in the same sequence that the user models were instantiated. This enabled a profile to be constructed that could identify any

possible correlation between when the pupils logged-in in relation to their peers and the

effect upon their visit concurrency. This example shows a profile from trial 1. The first 4

pupils to log-in show high levels of congruence with the courseware design intent in

relation to their visit concurrency profiles. However, there is a notable shift away from

congruence with pupils who log in after these first four pupils.

School A Trial 1 Computer 2 Visit Concurrency

Fig. 43

Data was extracted from the user models to indicate the levels of courseware

completion by log in order. This enabled a profile to be constructed that could identify

any possible correlation between log-in order and courseware completion. This example

(fig. 44) shows no correlation between courseware completion and log-in order.

School A Trial 1 Computer 2 Courseware completion by log In Order
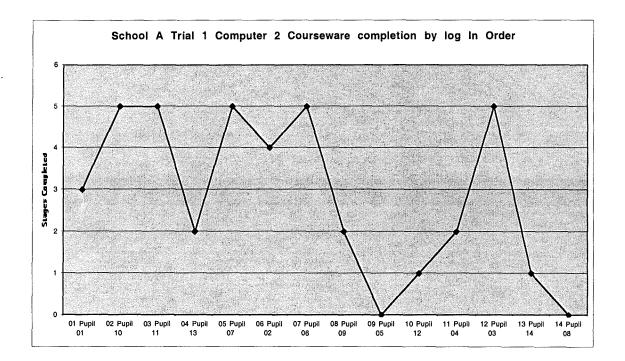
Fig. 44

It was possible to compare these two profiles to identify whether there was any correlation between courseware completion and visit concurrency. In the examples shown there is a peak of courseware completion around a group of pupils (5,6 and 7 from 14) and an individual (12 from 14). These peaks are also evident in the visit concurrency profiles by log-in order, which shows similar peaks in CVs for the same group and the same individual. This would indicate some possibility that pupils who adopt a concurrent visit strategy in this learning milieu were more successful in completing the courseware and should become a factor in the significant and concomitant features emerging from the trial.

The Systems Built Profile

Data was extracted from the user models to indicate what options from the possible range of alarm systems supported by the courseware had been constructed. This was presented in the form of a histogram where the various input options were clustered together. By comparing data from across the trials is was possible to establish an average response from trial 1. This was necessary as the alarm systems have differing levels of 'usefulness' and applicability to the likely range of application contexts explored, e.g. a bulb would be an uncommon output component to choose and a wire loop is applicable to less contexts than a microswitch. Hence, a flat response would not indicate that pupils had been using the courseware in an open way to satisfy their own project aims, but a profile that was close to the average response from across the trials would give a more accurate indication. It is evident that this 'average' will become more accurate as the number of trials increases, as atypical responses will have a less significant effect upon it. However, in this current research it was sufficient to give an indication of the typicality of pupils responses to the design briefs that were set for them and was useful in triangulating with the features that were concerned with the task type that the courseware had been used to support .

The example (overleaf) shows a trial 1 response. The darker bars show the average response from across all schools in trial 1. The lighter bars indicate the response from this trial group. The definite cluster around a light-beam input would indicate that concomitance with another significant feature from the trial, probably concerned with task type should be sought.

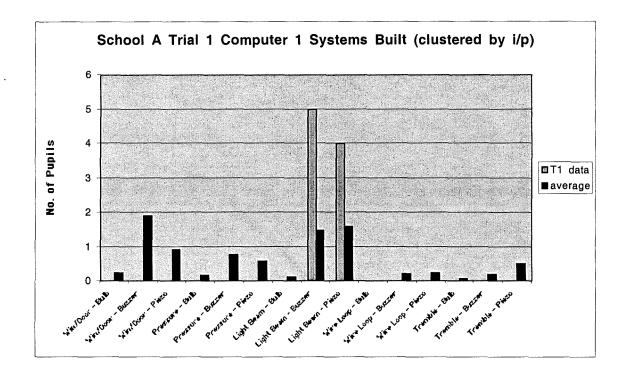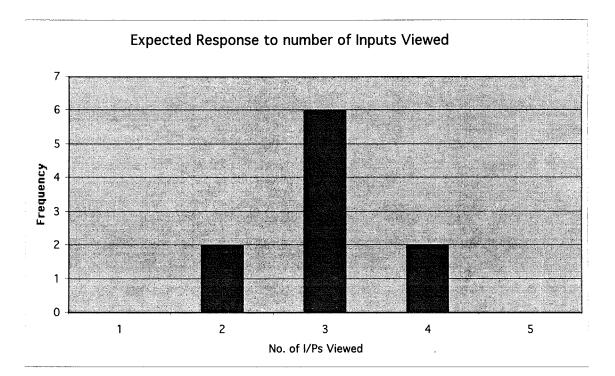**School A Trial 1 Computer 1 Systems Built (clustered by i/p)**

Fig. 45

The Systems Modification and Design Visit Profiles

Data was extracted from the user models to indicate how many pupils had made

changes to their initial decisions with regard to how their alarm circuit would function.

This was presented as a simple table with three numerical components: the number of

opportunities that were available for pupils to make changes to their system (equivalent

to the number of visits made to C2); the number of changes made; and the percentage

that these changes represented in relation to the number of opportunities to make

changes. Pupils making changes to their initial design decisions would indicate

productive interplay between action and reflection in the furtherance of their design

objectives and the ability of the courseware to facilitate changes as they become

necessary.

Data was also extracted from the user models to indicate how many options pupils had

explored when making their initial design visits to cluster 1. This data was presented as

a frequency distribution. The example shown (below) represents an expected response from a group of users in relation to the number of inputs viewed. If a pupil is approaching the courseware with a design agenda they will have an application context in mind. Once they understand the overall operating characteristics of the alarm system supported by the courseware there will be a number of options that have the potential to satisfy their individual needs. The possibilities in a typical range of project outcomes are most likely to reside in the mid regions of the availability scale, i.e. there is likely to be more than one method, applicable to the users working context, of triggering the alarm and it is unlikely that all five will be applicable. Hence, a peak should be evident in the profile somewhere in the mid regions of the scale.

These two profiles both relate to the levels of heuristic interaction with the courseware. If pupils have a design agenda (factors relating to the learning milieu) and the courseware is effective in content and operation (factors relating to the development paradigm) then heuristic interaction with the knowledge base should result.

Expected Response to number of Inputs Viewed

Fig. 46

Analytical Process

The analytical process has been outlined in section 3 of this chapter. A more detailed description is provided here.

The case studies were written up using the following process:

• A 'pen picture' of the school was provided by using the introductory paragraphs from the relevant Office for Standards in Education (OFSTED) reports. These reports enable the school to be set in context for the reader in an objective manner and provide information regarding the ethos, intake and locations of the schools.

• A 'pen picture' of the Design and Technology departments was provided by the researcher. These sections aim to set the department (location, staff, resources, subject take-up by pupils at KS4 and above) in context for the reader.

• Information regarding the resources used for the trial (rooms, computers, staff and group numbers)

• At the end of each trial the used courseware was collected and the participating teachers were interviewed using the appropriate interview schedule.

• The interviews were tagged and rearranged to provide a reflective account in areas that relate to the courseware specification criteria.

• The modified interview schedules were used to construct a commentary on the trial. The outcome of the commentary was a list of major issues to be investigated and triangulated against the user model data.

• The user model data was used to construct the charts and tables, as detailed earlier in this section, which were presented with a commentary to highlight their significance.

• The charts, tables and their commentary were used to construct a courseware data commentary that triangulated the quantitative and qualitative data from the trial.

• A list of significant features from the trial was constructed as a result of this commentary and triangulation process.

• The concomitant relationships between these significant features was then established. These relationships were presented in the form of a causal network diagram using a what/why? linking structure. A superior level feature is linked to a subordinate level feature by asking the question, "What will this feature cause in this learning milieu?". The links are traversable in the opposite direction from subordinate to superior by asking the question, "Why has this feature occurred in this learning milieu?". This form of causal network diagram enabled a clear and direct view of the significant feature dynamic to be obtained for each trial.

• When all of the case studies were complete the concomitant features from the trials were considered collectively. This enabled the critical processes from the trails to emerge and be formulated. They were discussed and presented in diagrammatic form.

• The four critical processes to emerge were used as a basis to understand what the potential was for further development of both the courseware prototype and courseware development paradigm.

Chapter 4 - The Case Studies

Section 1 - School A

The school is a boys' school with a long tradition going back more than 400 years. it is located in the centre of [North London Town] on the perimeter of London. It serves a wide area and receives its pupils from 27 main primary schools and at least 40 others. The socio-economic circumstances of most of the pupils are in line with the national average. It is an above average sized comprehensive school of 1112 boys. There were 1091 when the school was last inspected. It is a grant-maintained school. Though called a 'grammar school' it is in fact a 'comprehensive' school. There are pupils of all abilities in the school with slightly more average or above average ability pupils than in similar schools. There is an above average sized sixth form of 226 pupils; there were 185 when the school was previously inspected. One hundred and twenty-five pupils are on the register of special educational needs. Nineteen percent of pupils have special educational needs. This is above average. Sixty-six have learning difficulties which include dyslexia, five have emotional difficulties and five moderate learning difficulties. There are 13 pupils with statements of special educational needs; there was one when the school was last inspected. More than nine out of ten pupils remain in full-time education at the age of 16. Eighty-five percent of students leaving the sixth form progress into further or higher education. This is above average. There is a wide ethnic diversity in the pupils with at least 20 ethnic backgrounds and 30 home languages represented.

(OFSTED)

School A is a split site school; the two sites being approximately 0.25 miles apart. The lower school site accommodates years 7 and 8 and the upper school site the remainder. Both sites centre around historic buildings along with more modern extensions and outbuildings. Design and Technology is located in facilities that were newly built one school year before the first trial began. These facilities are on the lower school site and pupils from year 9 upwards travel back to the lower school for their Design and Technology lessons and to do any follow-up work. The only other subject in the school with these arrangements is Music, which is located in an adjoining building. All other subjects in the school have facilities on both sites.

The Design and Technology Department

The new buildings for Design and Technology were a considerable improvement in facilities for the subject. Prior to this the subject was located in a range of porta-cabins equipped as workshops and non-specialist classrooms. When the trial period began the subject had moved in to the new buildings with all existing machinery and equipment having been relocated and made operational. The new buildings had been newly furnished (chairs, stools, benching, etc.) but no new equipment had been purchased. The new building has been arranged as four separate work areas with two on the lower floor and two on the upper floor. The two lower floor rooms have been equipped for resistant materials. One of the upper floor rooms has been equipped for textiles and the other for systems and control/graphics. There are no facilities for Food Technology. There is a centralised materials store and staff office in the centre of the lower floor, which can be accessed from both resistant materials workshops. The textiles room has its own dedicated store cupboards and similarly in systems and control most specialist consumable materials are stored in cupboards in that room. However, general construction materials have to be obtained from the store on the lower floor. It is general practice in all time-tabled lessons that pupils work in one room. However, 6th form students appear to have largely open-access to the facilities outside group contact sessions.

At the time of the trial the department was staffed by 4 full-time teachers (3 male, 1 female) with a variety of experience and expertise. In Key Stage 3 all staff teach in the 3 subject areas offered - resistant materials, systems and control and textiles. In key stage 4 staff with specialist expertise took responsibility for GCSE groups. At the trial time there were two resistant materials G.C.S.E. groups and one systems and control G.C.S.E. group. One member of staff coordinated the sixth form group with others contributing expertise and tutorial advice where necessary. There was one part-time technician whose principal responsibility was for materials preparation and supply. The staff group was lead by a Head of Department although one other senior member still

retained the title of Technology Coordinator. This was explained as an historical legacy

from the first iteration of the National Curriculum when there were strong links between

Design and Technology and information technology. Those links were no longer in

place and the technology coordinator had no reported management responsibilities for

the subject. From the two remaining teaching staff one has been given the role of second

in department and the other was newly appointed. Fig. 47 shows a diagram of the

department structure, expertise and responsibilities. It also indicates which staff took
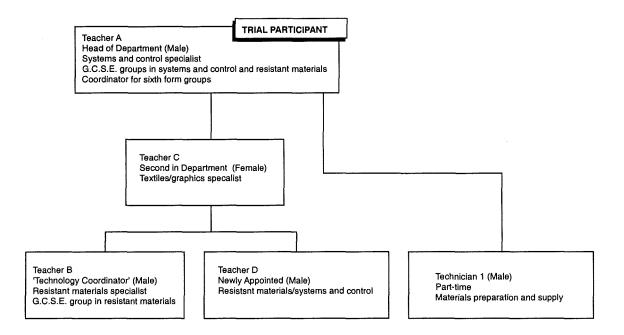
part in the trials.

Fig. 47 School A Design and Technology Department Staff Structure

Background to the Trials

As Head of Department Teacher A had been willing to participate in the trial. At the

time of the trial KS3 pupils were taught on a 'subject circus' arrangement where their

teachers followed them from subject area to subject area within Design and Technology.

As previously mentioned this involved all teaching staff in all subject areas at key stage

3 regardless of their individual specialism. This delivery model was also referred to as a

'skills round' by Teacher A. Teacher A had been willing to participate as he was

responsible for two year 9 groups in that school year and had stated that he was open to new developments and was looking for ways to develop the curriculum. During the first school term Teacher C would also be teaching a year 9 systems and control group. However, it was teacher A's view that Teacher C should continue with their normal practice (a type A task based on logic gates) as she had experienced that project before and was comfortable with teaching it despite her lack of in-depth subject knowledge. Teachers B and D would not be teaching any year 9 systems and control groups until later in the school year, so consequently were not eligible for the first stage of the trial.

The trial setting was the systems and control room on the upper floor of the Design and Technology block. Two Macintosh LC computers were available, both of which had a styleWriter printer connected. The Macintosh computers had been used extensively in the department by pupils and staff. From the software installed (Claris Works 2, MacWrite 2 and MacDraw 2), discussions with teacher A and work displays it appeared that they had mainly been used for word processing and basic drawing in the embellishment of project folder work by pupils. These were the only two computers in the Design and Technology pupil work areas. However, there was a newly purchased PC in the central store/office, which was connected to the school network. The IT department had a network of PCs, but these were located at the upper school site. Teacher A was expecting a number of new PC computers to be purchased in the near future. His principle aim was to use them for CAD/CAM work and computer control; areas that he felt were lacking in their curriculum. He saw a limited future for the two Macintosh computers as many pupils now had PCs at home and the school purchasing policy had moved inexorably in the PC direction. At the beginning of the trial both Macintosh computers were functional. One was sited in a lower floor resistant materials workshop and the other was on a trolley in the central store/office area. After the courseware was installed and demonstrated the computers and printers were moved to the trial room. Advice about their positioning was sought from this researcher by Teacher A. The advice given by this researcher related only to the audio output from the

courseware and, hence, it might be beneficial if the machines were in separate positions. Fig. 48 shows the room layout for the school A trial.

```
 ┌──────────────────────────────────────────────────────┐
 │ ┌──────────┐                                          │
 │ │ Printer 1│                          Side Benching   │
 │ └──────────┘                                          │
 │      ┌────────────┐        ┌─────────────────────────┐│
 │      │ Computer 1 │        │                    S    ││
 │      └────────────┘        │                    i    ││
 │                            │                    d    ││
 │   ┌─────────────────────┐  │                    e    ││
 │   │                     │  │                    B    ││
 │   │                     │  │                    e    ││
 │   │                     │  │                    n    ││
 │   │                     │  │                    c    ││
 │   │                     │  │                    h    ││
 │   │   Pupils' Benches   │  │                    i    ││
 │   │                     │  │                    n    ││
 │   │                     │  │                    g    ││
 │   │                     │  │   ┌──────────┐            │
 │   │                     │  │   │ Computer 2│  ┌────┐   │
 │   └─────────────────────┘  │   └──────────┘  │Pri-│   │
 │                            │                 │nter│   │
 │                            │                 │ 2  │   │
 │          ┌──────┐          │                 └────┘   │
 │          │ OHP  │          │                          │
 │          └──────┘          │                          │
 │       ┌──────────────┐     │              M           │
 │       │Teachers' Desk│     │              a           │
 │       └──────────────┘     │              i           │
 │                            │              n           │
 │                            │                          │
 │                            │              D           │
 │     ┌─────────────────────┐│              o           │
 │     │Chalk Board + OHP     ││              o           │
 │     │        Screen        ││              r           │
 │     └─────────────────────┘└──────────────────────────┘
 └──────────────────────────────────────────────────────┘
```
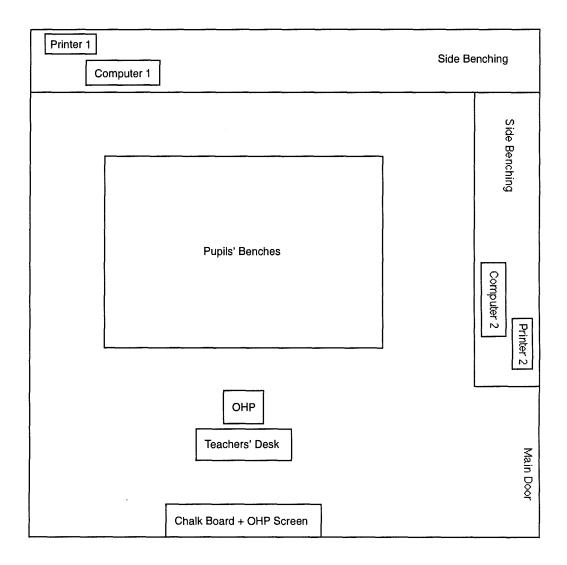
Fig. 48 School A trial room layout.

Trial 1

The first trial took place with a group of 23 year 9 boys over a time period of 6 weeks in the Autumn term; 6 week blocks are allocated by the department for the 'subject circus' arrangement described above. There were some problems reported with one computer during this first trial period, which were described as 'crashing'. When investigated the courseware would not boot. It was subsequently found that the hyperCard software installation had become corrupted. HyperCard was reinstalled, the hardware (Computer,

printer and mouse) were checked for faults and the Macintosh desktop file rebuilt. The courseware was 'reset' by removing the partially compete data from the last user model to be invoked. The integrity of the remaining data sets that comprise the user models were checked and found to be complete and representative. This fault caused one week of lesson time to be lost, in week 3 of the trial, for the group of pupils who were using computer number 2. When the used courseware was collected at the end of the trial it was still fully functional.

In line with the project methodology model developed for this current research project Teacher A was interviewed after the first trial was completed using the trial 1 interview schedule. The complete interview transcript is available in appendix 3.1

T1 Interview Commentary

Teacher A has a good level of expertise and experience in electronics. He has taught a wide range of ages covering the 11 to 18 age range. However, it is evident that much of this teaching at KS3 has been focused on type A tasks. This teaching approach is often concomitant with the 'skills round' delivery model, referred to in the background to the trials, where pupils go through a series of focused practical tasks (FPTs), or design and make assignments (DMAs) that are very tightly framed, in a variety of singular material areas and often in a short time-frame; essentially activities that are in the lower reaches of the learning continuum [Page 21]. His use of computers and software in his teaching has been limited to a small set of generic applications. He has no experience of using courseware or computer based information sources in his teaching.

Teacher A reports a generally successful trial with good compliance to specifications 7a and 7b. However, there were major issues concerning compliance with specification 1&2. He reports difficulties with using the courseware on two Macintosh LC Computers. These difficulties focus on waiting for computer access causing some pupils to opt out of using the courseware by copying other pupils work. He also reports difficulties with printers indicating that they may not have been set up and tested prior

to each lesson, which may also have led to pupil opt-out. He estimates that he would

need 5 computers to adequately support the project, "...the way that I would teach it

anyway".

Major Issues

• Indications of possible task type mismatch
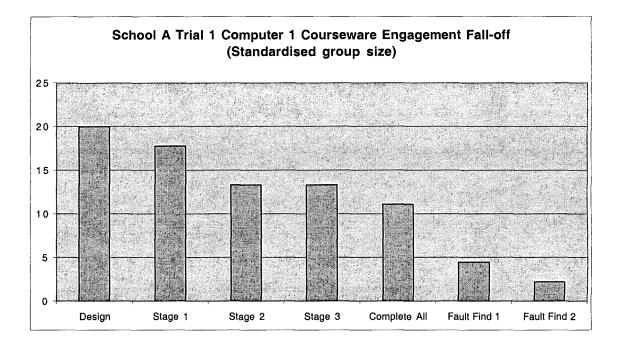
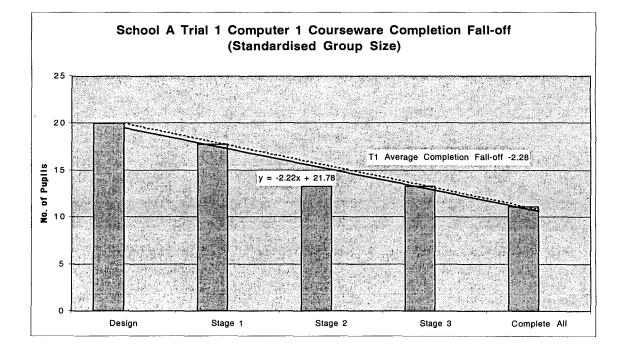• Waiting for computer access

• Pupil opt out

T1 Courseware Data

The level of deviant courseware interaction was low (The lowest in all trials in all

schools). Computer 1 showing exceptionally low levels of deviant interaction. The

deviant interactions were all premature switch-offs. There were no spurious log-ins or

pupils logging in to both computers. There were no duplicate log-ins caused by pupils

miss-spelling their names or inserting too many spaces between them.

	Total Log-ins	Deviancy rate	Deviancy Level
SAT1 C1	9	1.00	0.11
SAT1 C2	14	1.00	0.29
			0.20
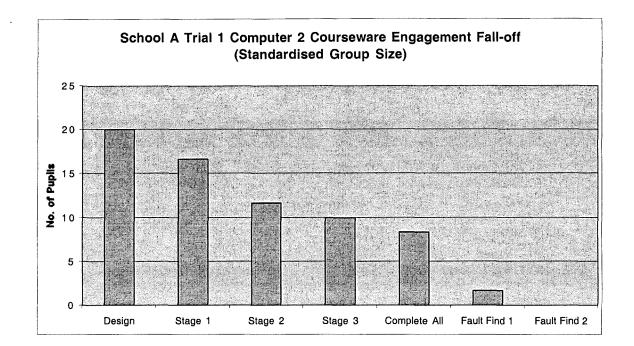
Fig. 49
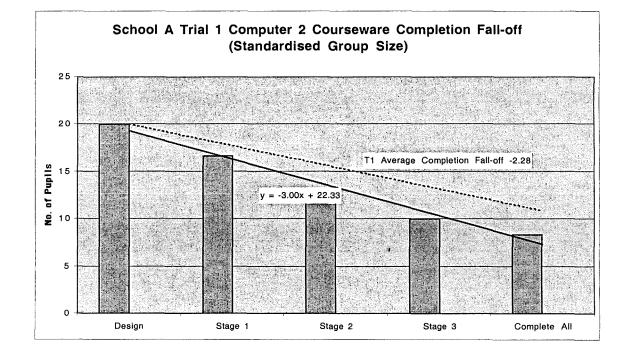
The courseware completion fall-off gradients were close to average (T1 average -

2.28 fall-off gradient = 54% completion rate). Computer 1 shows a slightly better than

average performance (-2.22) whereas computer 2 is slightly below average (-3.0). The

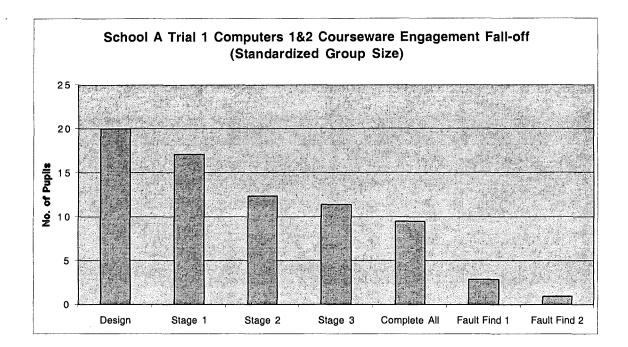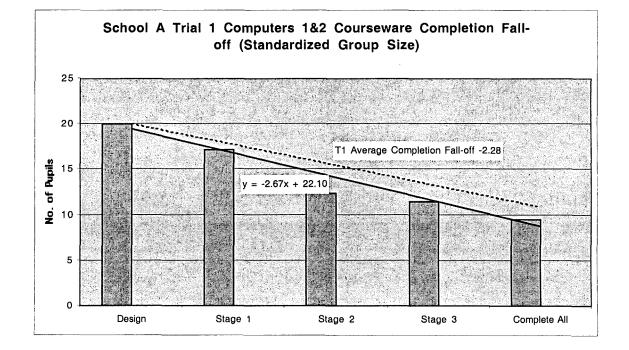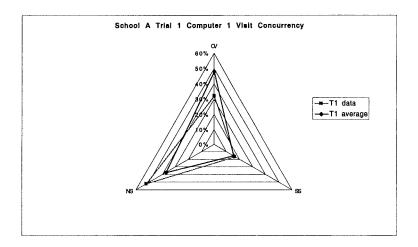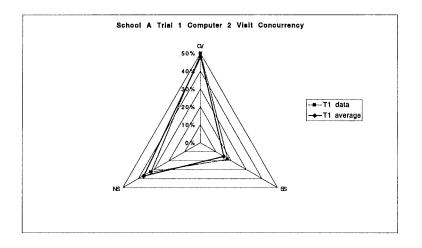courseware completion fall-off gradient for the trial being -2.67 which is slightly below

average.

School A Trial 1 Computer 1 Courseware Engagement Fall-off (Standardised group size)

School A Trial 1 Computer 1 Courseware Completion Fall-off (Standardised Group Size)

T1 Average Completion Fall-off -2.28

$y = -2.22x + 21.78$

Fig. 50

School A Trial 1 Computer 2 Courseware Engagement Fall-off (Standardised Group Size)

No. of Pupils

- Design
- Stage 1
- Stage 2
- Stage 3
- Complete All
- Fault Find 1
- Fault Find 2

School A Trial 1 Computer 2 Courseware Completion Fall-off (Standardised Group Size)

No. of Pupils

T1 Average Completion Fall-off -2.28

$y = -3.00x + 22.33$

- Design
- Stage 1
- Stage 2
- Stage 3
- Complete All

Fig. 51

School A Trial 1 Computers 1&2 Courseware Engagement Fall-off (Standardized Group Size)

School A Trial 1 Computers 1&2 Courseware Completion Fall-off (Standardized Group Size)

T1 Average Completion Fall-off -2.28

$y = -2.67x + 22.10$

Fig. 52

The overall visit concurrency profile for the trial was close to average with a small

positive shift away from CVs towards NS and SS visits. This shift was more marked in

computer 1 than in computer 2, although still small in size.

School A Trial 1 Computer 1 Visit Concurrency

School A Trial 1 Computer 2 Visit Concurrency

School A Trial 1 Computers 1&2 Visit Concurrency

Fig. 53
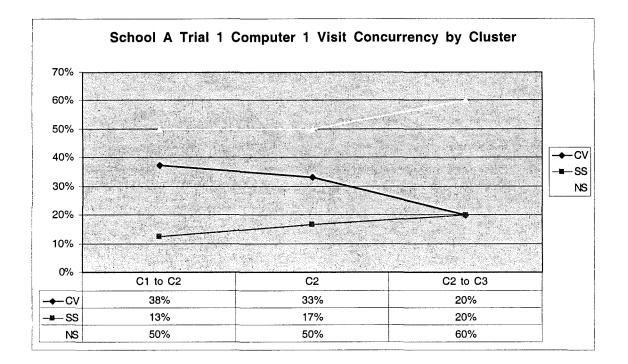
There was a notable difference in visit concurrency by cluster between the two computers.

Computer 1 shows reasonably high levels (50%) of NS visits in the C1 to C2 transition phase. There are increases in both SS and NS visits during the C2 and C2 to C3 transition phases, with a commensurate fall in CVs. **This profile represents a medium level of congruence with the intended courseware interaction.** The overall NS profile contributes positively to this congruence, but the high levels of CVs (38%) in the C1 to C2 transition are a negative feature.

School A Trial 1 Computer 1 Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
CV	38%	33%	20%
SS	13%	17%	20%
NS	50%	50%	60%

Fig. 54

Computer 2 shows high levels (60%) of CVs in the C1 to C2 transition phase. The level of CVs diminishes over the next two phases, but they remain as the dominant feature in this profile. **This profile represents a low level of congruence with the intended courseware interaction.**

School A Trial 1 Computer 2 Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
CV	60%	46%	40%
SS	20%	15%	20%
NS	20%	38%	40%
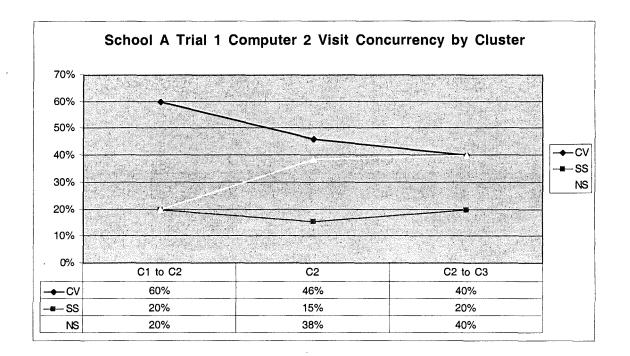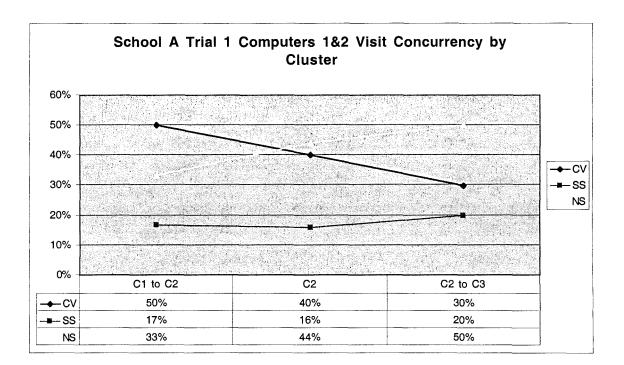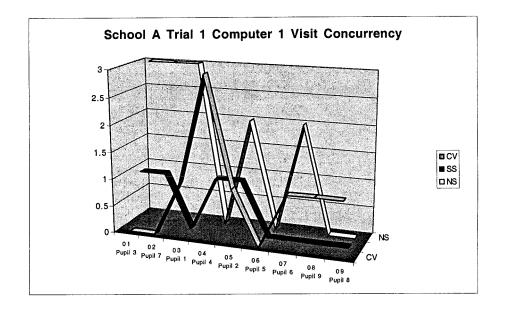
Fig. 55

The combined profile shows a low congruence start and a medium congruence end commensurate with the differing performance across each of the computers.
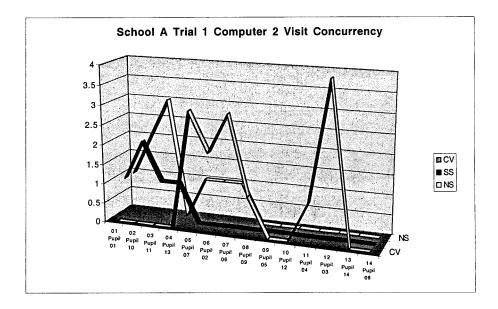
School A Trial 1 Computers 1&2 Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
CV	50%	40%	30%
SS	17%	16%	20%
NS	33%	44%	50%

Fig. 56

The visit concurrency by pupil log-in shows no overall trends across the two computer user groups. On computer 1 the CVs are concentrated around one pupil (4 from 9) with no other significant peaks apparent.

Fig. 57

On computer 2 the CVs are concentrated around one group of pupils (5,6 and 7 from 14) and an individual (12 from 14).

Fig. 58

The courseware completion by log-in order profile for computer 1 shows a definite trend. Courseware completion is 100% until pupil 5. Completions then tail off dramatically.
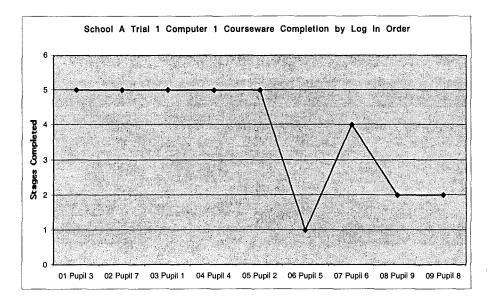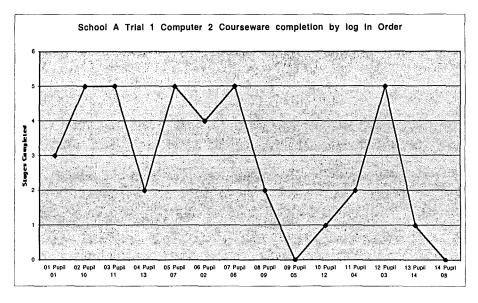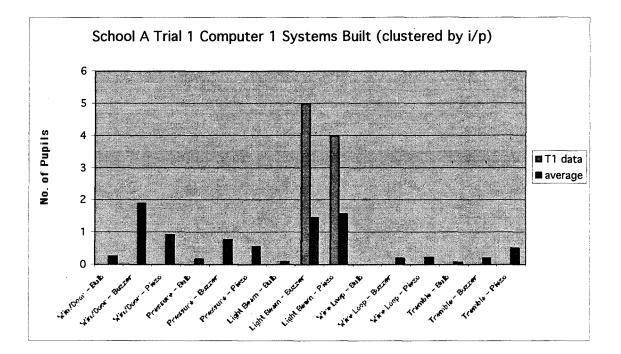
Fig. 59
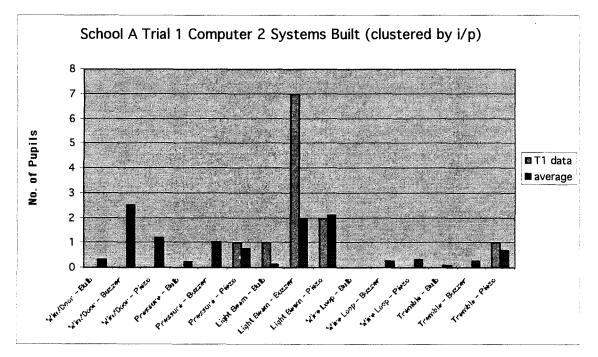
The courseware completion by log-in order profile for computer 2 shows no definite trend. However, there is a notable correlation between this profile and the CV component of the visit concurrency by pupil log-in. Again there is a peak of courseware completion around the same group of pupils (5,6 and 7 from 14) and the same individual (12 from 14).

Fig. 60

The systems built profile shows a marked clump around a 'light beam' input for both computers. All pupils using computer 1 have used this input (9 pupils), which is over twice the trial average for this group size for both outputs. Only two pupils using computer 2 have not used the 'light beam' input and they did not complete cluster 2 of the courseware.
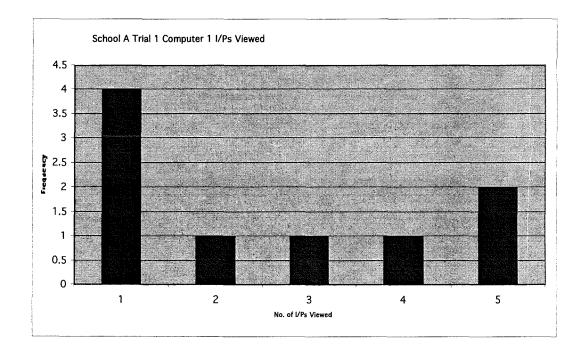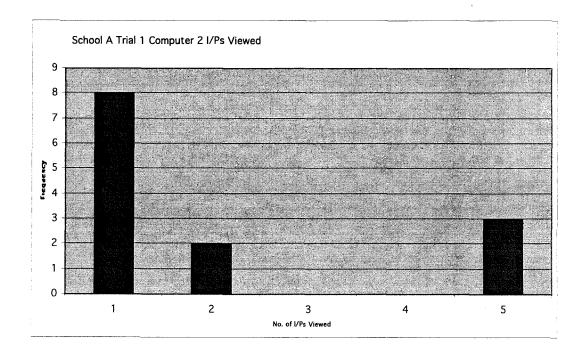

Fig. 61

The systems modification profiles and design visit profiles indicate low levels of heuristic interaction with the courseware. One pupil in each computer group made a change to their system, both of these being on the second visit. The pupil on computer 1 changed from a buzzer to a piezo sounder output (a probable improvement in system performance) whilst the pupil on computer 2 changed both the system input and output from a win\door switch with buzzer to a pressure pad with piezo sounder (a possible better match with application context).

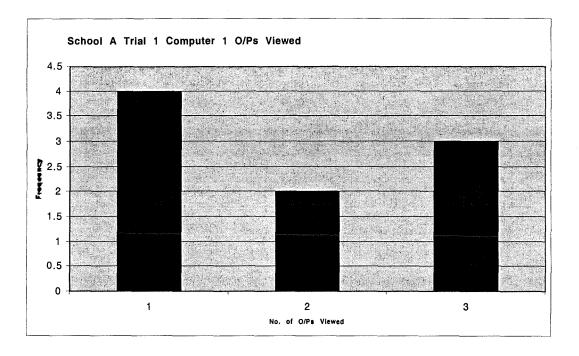| SAT1	Change Possibility	System Changes	
Computer 1	23	1	4%
Computer 2	23	1	4%

Fig. 62

The design visit profiles show a low level of compatibility with heuristic approaches to the use of C1, the profile curves being the inverse of a compatible distribution.
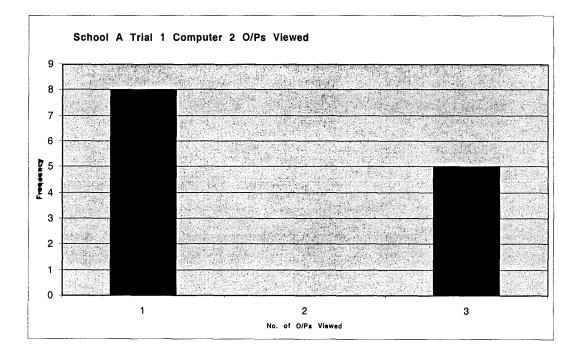

Fig. 63

School A Trial 1 Computer 1 O/Ps Viewed

School A Trial 1 Computer 2 O/Ps Viewed

Fig. 64

T1 Courseware Data Commentary

The data indicate a difference in performance for computer 1 and computer 2 across a range of aspects. Some of this performance difference might be attributed to the loss of part of the week 3 lesson as explained in the background to this trial. Although small in actual size its relative size in a six week project time-span may have been significant. It may also be significant that computer 2 had more users than computer 1 (14 against 9). There are no systematic indicators from the data as to why this should have been the case, e.g. log in by name order. However, it was evident that the class had been split into two groups either by the teacher, or by self-selection, as the level of deviant courseware interaction was exceptionally low and there were no instances of pupils logging in to both computers. On a global level it might be expected that this loss of time will be reflected by a steeper courseware completion fall-off gradient and a potential upwards trend in the visit concurrency by cluster during the later phases of courseware interaction. However, not only is the difference in completion fall-off gradients relatively small, but the level of CVs in the visit concurrency profile for computer 2 is highest in the initial phase and drops steadily away as the phases continue.

When the data regarding performance by pupil log-in order are examined differences in pupil behaviour begin to emerge. On computer 1 the level of visit concurrency by pupil log-in order is relatively flat across the range apart from one peak centred upon and individual (4 from 9). The courseware completion by log-in order indicates that the first 5 pupils to log-in completed all of the major visits. The completion rate then falls away. This profile indicates that the overall time-span for the project may have been limiting to the last four pupils to log in, even though the levels of visit concurrency were average for this group. Overall this group's use of the courseware is good with regard to visit concurrency and completion and largely congruent with the courseware design intent in these aspects. On computer 2 a very different pair of profiles is evident, which indicate a difference in pupil behaviour in this group. The visit concurrency by log-in order

shows a high level of visit concurrency concentrated around one group of pupils (5,6 and 7 from 14) and an individual (12 from 14). There is a correlation of this profile in the courseware completion by log-in order. This correlation indicates that these pupils adopted a concurrent visit strategy in order to complete the courseware within the given time-frame. This adopted strategy might be related to the loss of the portion of the week three lesson time on this computer. However, the visit concurrency by cluster is highest in the C1 to C2 phase and then gradually falls away. If this were the case, then it would indicate that only 4 pupils had logged in to the courseware in the first three weeks; an untenable explanation. Hence, there must be other explanations for this adopted behaviour.

This trial was completed in a six week time span, which was the shortest across the trial range. The pressure would have been high to complete the work in the given time. However, this time span would have been sufficient to complete the electronics component of a Type C task. However, the singularity of the systems built profile is startling. Indications of a possible task type mismatch from the interview may provide some insight into this phenomenon. The teacher could have briefed the pupils to produce for example, 'A light sensing circuit' (Task type A - make THIS circuit) . Although feasible, this would not explain the two responses from computer 2 that did not use this input. Furthermore, in response to the question about monitoring pupil progress part of Teacher A's response was, "Well only that they all did the same", indicating some level of surprise that this had occurred. A second explanation might come from Teacher A's observations that some of the pupils were, 'copying'. However, all twenty-three pupils had logged in to one of the computers. Twenty-one of them had completed at least the design visit (C1) and had made their system choices. There were also only two instances of changes to these choices and they did not affect the 'clump' size. These data indicate that the incidents of 'copying' must relate to work in the latter phases of courseware interaction and could more usefully be termed as pupil opt-out.

In light of the circus arrangement in the departmental delivery model and the KS3 'Skills round', a more likely explanation is that Teacher A required his pupils to gain experience at simply making a circuit as he had done in previous work. Hence, a type B task (make A circuit) could have been set, but without recourse to any particular general or personal application context for the electronics. This scenario would have left the pupils open to make any choices they saw fit from the courseware without any clear justification of the reasons for making those choices. Why then would they all choose to do virtually the same thing? Two factors may have contributed to this outcome in the proposed scenario. Firstly, the 'light beam' input is by far the most exotic of the 5 possible choices. It uses the most 'high-tech' components, the light dependent resistor (LDR) is the most expensive single component and, given no application context, its perceived value is clearly the highest of the available options to a year 9 boy. Secondly peer pressure, or the desire/willingness to conform to a group or subgroup norm. Why peer pressure might be particularly strong in this learning milieu is beyond the scope of this current research project, but some evidence is provided by the performance variation across the two computers and particularly with regard to the adopted behaviour in the computer 2 group. It is evident that the class split up in to two roughly equal groups and that these groups were each assigned to a computer (extremely low level of deviant courseware interaction and zero cross-machine log-ins). In this scenario, if peer pressure or the desire to conform to a subgroup norm was high, the initial phase of pupil interaction would set up the subsequent interaction behaviour of the subgroup. Working in this scenario where groups have been assigned to computers requires them to cooperate and formulate some form of 'turn' system, particularly if there is little project work to do other than complete the circuit. Pupils would be waiting for their turn on the computer and intra-group turn taking rules may have been set up. The indications of pupil-opt out, brought about by this waiting, coupled with the evident desire to pursue a singular outcome, indicate that as the project progressed using the courseware in a congruent manner to its design intent became contrary to the pupils' 'practicality ethic'. They could achieve what they needed to achieve by other means and these alternative strategies were still acceptable to Teacher A's overall objectives. It

might also be conjectured that a reason for the exceptionally low levels of deviant courseware interaction might be attributed to a lack of time for pupils to become deviant or the environment in which the trial took place.

T1 Significant Features

1. Indications of possible task type mismatch

2. Waiting for computer access

3. Pupil opt out

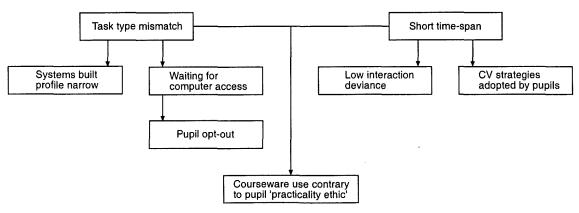4. Deviant courseware interaction level very low

5. Systems built profile very narrow

6. Concurrent visit strategies adopted by some pupils

7. Loss of congruence between the courseware design intent and the 'pupil practicality ethic'

8. Short time-span for project

T1 Concomitant Features

Fig. 65

Trial 2

Trial 2 took place with a different group of 23 year 9 boys over a time period of 6 weeks, in the same room, with the same teacher, during the following Spring term. This time no problems were reported with either of the computer systems and this researcher did not need to intervene. When the used courseware was collected at the end of the trial it was still fully functional.

In line with the project methodology model for this current research project Teacher A was interviewed after the second trial was completed using the adopters' interview schedule. The complete interview text is available in appendix 3.1.

T2 Interview Commentary

From the T2 feature breakdown it is evident that many of the major issues from T1 recurred. In this interview Teacher A makes the task type miss-match explicit and, hence, non-compliance with specification 6 becomes a significant feature of the trial. He has used the courseware to deliver a focused practical task (FPT), i.e. to build a circuit. The conjecture about a context free type B task from the T1 commentary is confirmed as pupils were given the opportunity to choose any outcome that they wished. Teacher A comments , "...to make sure that they have all constructed something, but of interest to them" supports this conjecture. However, designing circuitry 'of interest to them' cannot be supported by an application context in an FPT delivery mode. The FPT is inbuilt in the departmental teaching delivery model. Teacher A describes a teaching strategy where pupils undertake a range of FPTs, or 'resource tasks' followed by a design and make assignment (DMA) or 'capability task'. This strategy was advocated by G.C.S.E. syllabuses at the time of the trial, but was not inbuilt in the operating National Curriculum Document. It does not necessarily subscribe to the notions of a learning continuum, or framed tasks, as FPTs and DMAs can be polar opposites on a supposed learning continuum.

Teacher A again reports major issues regarding compliance with specification 1,2. He makes a link between the task type miss-match and the time-span available to compete the project and uses this notion to support his teaching strategy. He now estimates that seven computer systems would be needed to support the courseware (5 estimated in 1st trial) and then goes on to suggest that a dedicated computer room separate from the workshop would be a much better option. He again cites copying, waiting for computer access, a limited level of pupil interaction with the courseware and pupil opt-out as an inevitable consequence of trying to support the courseware use on two computers.

Teacher A recognises the importance of autonomous practice in the development of design capability. However, he is sceptical about whether he can achieve this with, "teenagers". He recognises the contribution that courseware of this type can make in supporting teachers who wish to promote pupil autonomy, but refers back to computer numbers as the limiting factor in this process.

Major Issues

• Task type mismatch

• Waiting for computer access

• Pupil opt out

• Possible non compliance with teacher's 'practicality ethic'
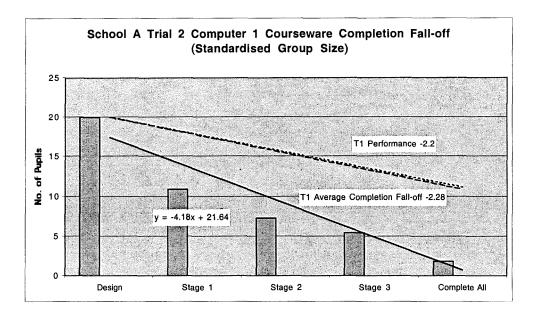
T2 Courseware Data

The level of deviant courseware interaction was low (the second lowest in all schools in all trials). In contrast to T1, computer 1 this time showed marginally higher levels of deviant interaction than computer 2. Both computers had suffered one premature switch-off each, but this time both had registered log-ins with miss-spelled names (2 different instances on computer 1 and 1 on computer 2). There were no spurious log-ins or pupils logging in to both computers.
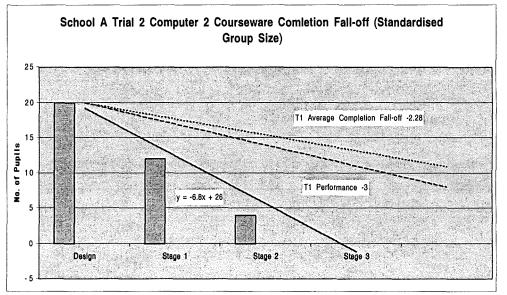
	Total Log-ins	Deviancy rate	Deviancy Level
SAT1 C1	12	1.00	0.25
SAT1 C2	11	1.00	0.18
			0.22

Fig. 66

The courseware completion fall-off gradients were significantly below average. Both computers showed fall-off gradients that were the steepest for all the schools in all the trials. In common with trial 1, computer 1 had performed slightly better (-4.18) than computer 2 (-6.8). On computer 1 only 1 pupil from 11 had completed the critical stages of the courseware. On computer 2 no pupils completed the courseware. Only 2 got as far as the second stage of cluster 2. The engagement fall-off gradients have not been provided as, under these circumstances, they give no more information than the completion gradients.
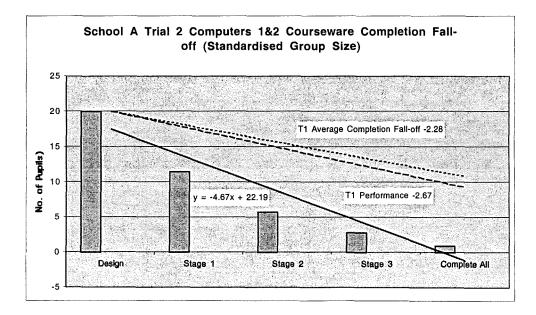
School A Trial 2 Computer 1 Courseware Completion Fall-off (Standardised Group Size)

T1 Performance -2.2

T1 Average Completion Fall-off -2.28

$y = -4.18x + 21.64$

School A Trial 2 Computer 2 Courseware Comletion Fall-off (Standardised Group Size)

T1 Average Completion Fall-off -2.28

$y = -6.8x + 26$

T1 Performance -3

School A Trial 2 Computers 1&2 Courseware Completion Fall-off (Standardised Group Size)

T1 Average Completion Fall-off -2.28

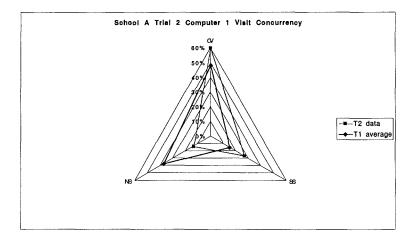$y = -4.67x + 22.19$
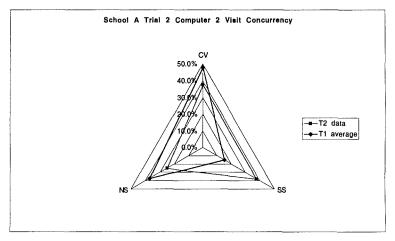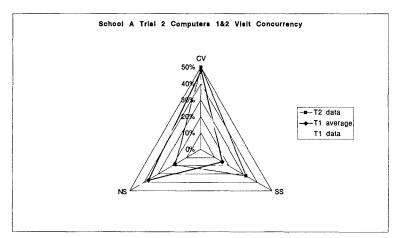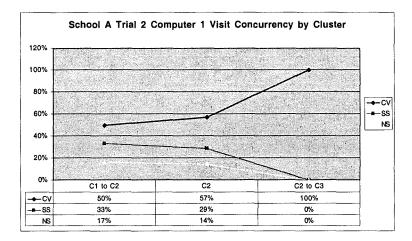
T1 Performance -2.67

Fig. 67

The overall visit concurrency profile for the trial had shifted considerably from the first trial. On computer 1 there was a considerable increase in both CVs and SS visits, with the commensurate reduction in NS visits. On computer 2 there was a large pull towards SS visits with a reduction in both CVs and NS visits. However, the very steep completion gradients (small number of pupils progressing through the courseware) should be borne in mind when considering these profiles.
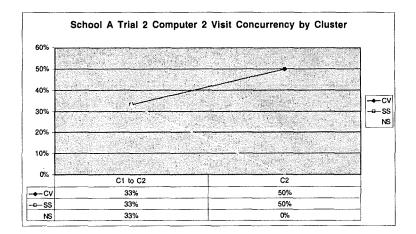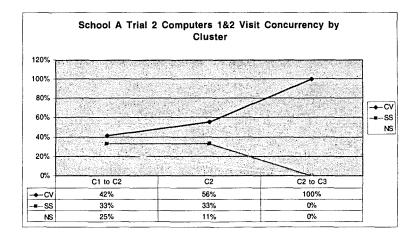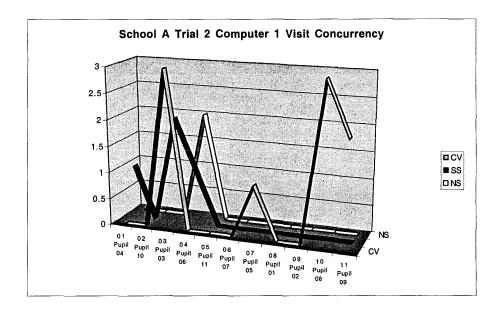

Fig. 68

The visit concurrency by cluster profiles were both dominated by CV and SS visits. Again the small number of pupils affecting the latter portions of these profiles should be remembered when considering them, e.g. the 50% CV in the C1 to C2 transition phase on computer 1 is derived from 11 pupils, whereas the 100% CV in the final part of this profile is derived from 1 pupil.

School A Trial 2 Computer 1 Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
CV	50%	57%	100%
SS	33%	29%	0%
NS	17%	14%	0%

School A Trial 2 Computer 2 Visit Concurrency by Cluster

	C1 to C2	C2
CV	33%	50%
SS	33%	50%
NS	33%	0%

School A Trial 2 Computers 1&2 Visit Concurrency by Cluster

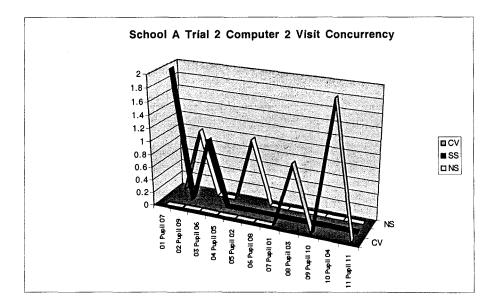|	C1 to C2	C2	C2 to C3
CV	42%	56%	100%
SS	33%	33%	0%
NS	25%	11%	0%

Fig. 69

The visit concurrency by pupil log-in shows no overall trends across the two computer user groups. On computer 1 the CVs are concentrated around the third pupil to log-in (3 from 11) and the final two (10 and 11 from 11).
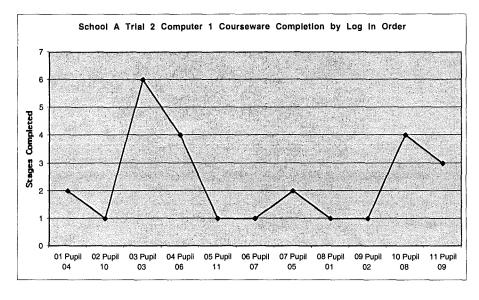
On computer 2 there are two CV peaks for pupil 8 and pupil 10.

Fig. 70
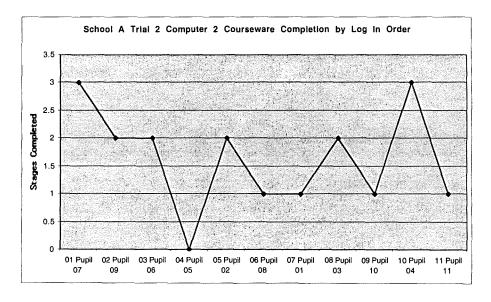
The courseware completion by log-in order profiles show no definite trends. However, there is the same correlation between this profile and the CV component of the visit concurrency by pupil log-in that was evident in trial 1. Pupils 3, 10 and 11 have peaks for both courseware completion and concurrent visits.

Fig. 71
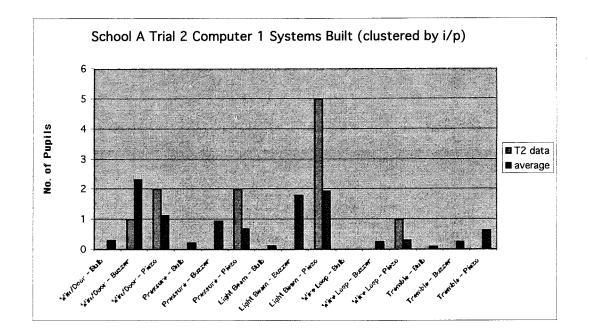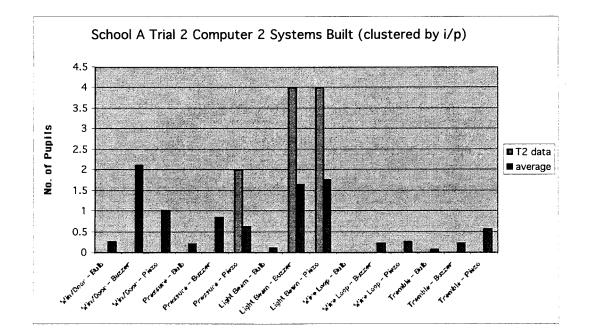
A similar correlation is evident for pupil 10 in the computer 2 user group. However, the correlation is not universal for the whole group. Pupil 1 attains the same level of completion but does so with SS visits.

Fig. 72

The systems built profile for both computers show a similar 'clump' around the light-beam input on both computers. This is more marked in computer 2 than in computer 1. There is some broadening of the profile on computer 1, but the light-beam/piezo combination is over twice the trial average for a group of this size.
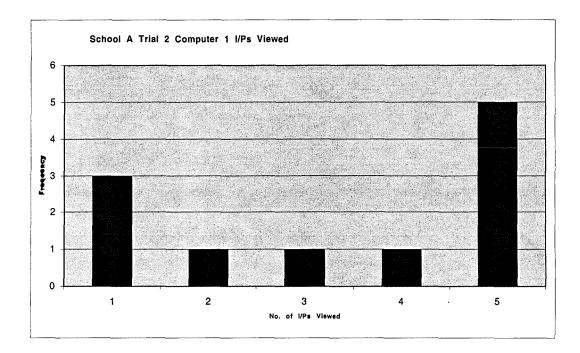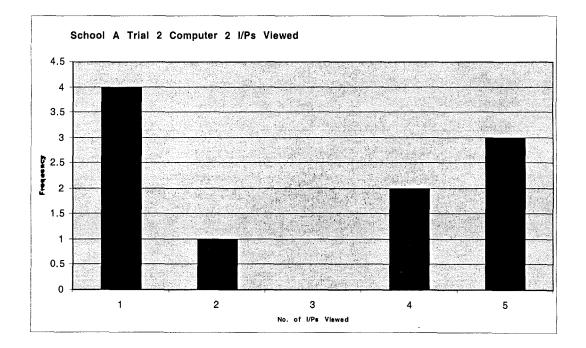
Fig. 73

The systems modification profiles and design visit profiles indicate low levels of heuristic interaction with the courseware. In common with trial 1 only 1 pupil in each computer group made a change to their system. The pupil on computer 1 changed from a light-beam/buzzer to a pressure-pad/piezo combination (a shift away from the group norm giving possible indications of an application context being considered) whilst the pupil on computer 2 changed the output from a piezo sounder to a buzzer (an overall degradation in system performance).
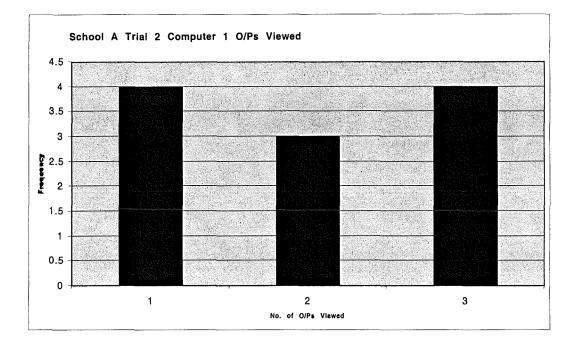
SAT2	Change Possibility	System Changes	
Computer 1	14	1	7%
Computer 2	8	1	13%
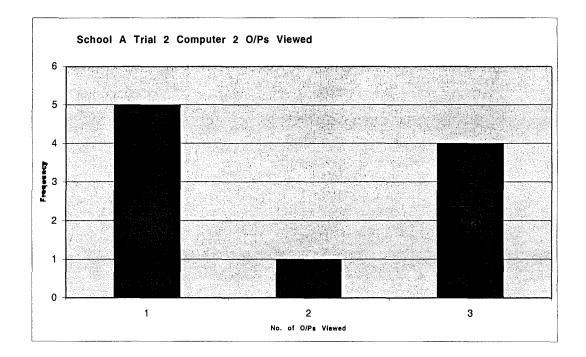
Fig. 74

The design visit profiles show a low level of compatibility with heuristic approaches to the use of C1, the profile curves being the inverse of a compatible distribution.

School A Trial 2 Computer 1 I/Ps Viewed

(Bar chart — Frequency vs No. of I/Ps Viewed: 1 = 3, 2 = 1, 3 = 1, 4 = 1, 5 = 5)

School A Trial 2 Computer 2 I/Ps Viewed

(Bar chart — Frequency vs No. of I/Ps Viewed: 1 = 4, 2 = 1, 3 = 0, 4 = 2, 5 = 3)

Fig. 75

School A Trial 2 Computer 1 O/Ps Viewed

School A Trial 2 Computer 2 O/Ps Viewed

Fig. 76

T2 Courseware Data Commentary

The data indicate a significant drop in performance in T2 as compared to T1. This is particularly evident in the courseware completion fall-off gradients which were the two steepest examples from all schools in all trials. The deviant courseware interaction profiles rose very slightly, but were still exceptionally low when compared to figures from other trials. These two profiles were the lowest for any school in any trial.

The very small completion rate bears heavily upon some of the percentage based profiles, e.g. in the visit concurreny profiles and the visit concurrency by cluster. However, there is a notable shift towards both CV and SS visits across the trial and particularly in those pupils who attained the highest levels of courseware completion. The same correlation between courseware completion by pupil log in order and the CV component of the visit concurrency by pupil log-in was evident as in T1. This again indicates that some pupils adopted a CV strategy in attempting to complete the work in the given time-frame.

In common with T1 the systems built profile was very narrow with the same clump around the light-beam input. There was some broadening out on computer 1, but the figures for the light-beam input were still over twice the expected average for the trial.
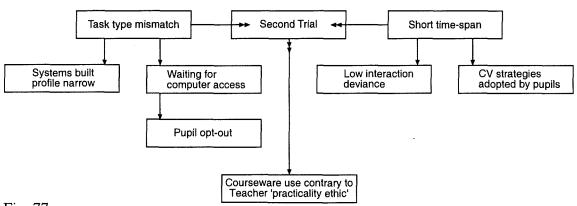
From the courseware data it is evident the pupils behaved in a very similar way in T2 to T1. However, there was a significant drop in performance with regard to the courseware completion fall-off gradients. Little had changed in the major variables in the learning milieu from T1 to T2 save for Teacher A now having experience of using the courseware on a previous occasion. Hence, this significant fall in performance can only reasonably be explained by a loss of compliance between the courseware design intent

and the Teacher A's practicality ethic. Teacher A has experience of how the courseware will not meet his needs in certain areas and is therefore more willing to allow pupils to complete the work without using it. The instances of pupil-opt out evident in the first trial have become legitimised by the teacher.

T2 Significant Features

1. Second Trial

2. Task type miss-match

3. Short time-span

4. Waiting for computer access

5. Pupil opt-out

6. Deviant courseware interaction low

7. Systems built profile narrow

8. Concurrent visit strategy adopted by some pupils

9. Loss of congruence between courseware design intent and teacher's practicality ethic

T2 Concomitant Features

Fig. 77

Chapter 4 - The Case Studies

Section 2 - School B

The school is for boys and girls between the ages of 11 and 18. It is growing in popularity, has 913 pupils and recruits from a very wide area. There are more boys than girls with a significant imbalance in year 9 and the Sixth Form. The proportion of pupils entitled to free school meals is more than twice the national average. Over half the pupils are from ethnic minorities and a slightly lower proportion have English as an additional language; about a quarter are refugees or asylum-seekers. Approximately 20% of the pupils arrive or leave the school at times other than the usual admission or leaving dates. The proportion of pupils with special educational needs, including those with statements, is high. The attainment of pupils who transfer from primary schools at the age of 11 is on average very low. The attainment of the most recent intake is higher but is still below average.

(OFSTED)

School B is a single site school situated in a residential area, quite close to a large north London town and the M25 motorway. It is surrounded by large playing fields that it shares with an adjacent leisure centre. The leisure centre facilities are also used by the school. This school was built in the 1970's to serve the expanding suburban population in the area. All buildings are from this period. There have been no recent, significant extra funds directed into this school via initiatives or grants.

The Design and Technology Department

The Design and Technology department is situated in the main body of the school in two separate clusters and an individual room. There is a suite of three adjoining workshops and a 'technology' room on the lower floor. There are dedicated rooms for

food and textiles, on the first floor above the workshop suite. There is also a separate graphics room set remotely from the main workshop suite.

The workshop suite is arranged as three adjoining rooms with glass partitions around a central store and office. Each workshop is equipped to a level that enables general Design and Technology work to take place, but there are three individual themes for each room; metalwork, woodwork and a cleaner graphics area. The 'Technology' room adjoins the centre workshop and is a small area behind a glass partition. It is possible to see all rooms from any individual room and all workshops have access to the tools and materials store. The flexible nature of the physical environment lends an efficiency to general Design and Technology activities. Pupils are allowed to move between rooms when lessons are under way whenever possible as this movement is relatively easy to manage. On the occasions when there is more than one class in the workshops the doors can be closed to provide quiet teaching rooms. The department is often used after school hours by G.C.S.E pupils to complete their coursework. There was also a thriving go-carting club, run by the Head of Technology, when the trials took place. There have been a limited number of 6th form students studying Design and Technology in recent years. They have open access to the facilities outside contact sessions.

At the time of the trial the department was staffed by 5 full-time and 2 part-time teachers (4 male, 3 female) with a variety of experience and expertise. The technology department is split into two 'subjects' Design and Technology and Home Economics. There was one technology coordinator who was also the head of Design and Technology. There was also a head of home economics. Most teachers had a general responsibility at KS3 within one of the two subjects; there was no 'cross-subject' teaching. In KS4 staff with specialist expertise took responsibility for the G.C.S.E. groups. At the time of the trial there were two resistant materials, one systems and control and one graphic products G.C.S.E. groups in Design and Technology. The Head of Design and Technology coordinated the sixth form students with others contributing expertise and tutorial advice where necessary. There was one full-time general

workshop technician. From the remaining teaching staff one was designated as the

second in department and taught across most areas. Another specialised in graphics and

only rarely took groups in the workshop. The final member of staff worked as a 0.5 in

Design and Technology and 0.5 in physical education. Fig. 78 shows a diagram of the

department structure, expertise and responsibilities. It also indicates which staff took

part in the trials.

TRIAL PARTICIPANT

Teacher A (Male)
Head of Technology
Head of Design and Technology
G.C.S.E. groups in resistant materials and systems and control
Coordinator of sixth form students

TRIAL PARTICIPANT

Teacher B (Male)
Second in department
Resistant materials specialist
G.C.S.E. group in resistant materials

| Teacher C (Male) Graphics specialist G.C.S.E group in graphic products | Teacher D (Male) 0.5 Resistant materials specialist KS3 teaching only | Technician 1 (Male) Full-time General workshop duties |

Fig. 78

Background to the Trials

As head of department Teacher A had been willing to participate in the trial. In KS3

pupils undertook a range of design and make assignments (DMAs) in the various

material areas. He would be taking one year 9 group in each school term. Teacher B

would also be taking a number of similar year 9 groups. He also became willing to take

part in the trial after the courseware was demonstrated to him. Both Teacher A and B

had been involved in similar project work in the past but no electronics had been done at

KS3 for three or four years. They both wanted to see it reintroduced and were seeking

ways to develop their curriculum and teaching.

The trial setting was in the workshop suite, with the courseware sited in the technology room. There was one ancient, but well used, Macintosh Plus (the only one that this researcher has ever seen) in the technology room with an external hard drive and a dot matrix, letterWriter printer attached. When the courseware was installed on this computer it ran very slowly indeed. This computer would not have been able to support the trial. The head of department was aware of a redundant Macintosh LC in home economics. This had become redundant since the installation of one PC in that department that was connected to the school network. The Macintosh LC was resited in the technology room and connected to the letterWriter printer. From the software installed on the Mac+ (MacDraw, MacWrite, MacDraft, MFA library files), discussions with Teacher A and work displays it appeared that this computer had been used for a range of word processing and basic drawing in the embellishment of project folder work by pupils. Teacher A had also constructed a set of printed circuit board (PCB) layout library files in MacDraw. These had been used by G.C.S.E CDT Technology pupils. They modelled systems using MFA (Microelectronics for all) modules, used the library files to produce a PCB layout and then realised the system. Teacher A reported good levels of success using this learning support system, although he had some reservations about the outcomes. These reservations were associated with the modular nature of MFA kits, which often caused the 'final solutions' to be over-engineered and to have excessive component counts for the function achieved. Teacher A had also used the computer to produce a variety of handouts for his G.C.S.E. groups although these were principally text based. This was the only computer available in the department. The school had recently installed a network of PCs. Teacher A reported that these were well used, but not currently as a part of Design and Technology teaching. The school offered general I.T classes in KS3 to all pupils in the network room and some pupils used them for G.C.S.E. IT. The school had begun to install remote machines connected to the network in various classrooms, but these had not yet reached Design and Technology. Both Teacher A and B wanted this to happen soon as there were no facilities in the department for either CAD/CAM or computer control work.

The courseware was installed as three separate versions in folders of the teachers

choices and named accordingly. Teacher A would be taking one group in T1 and Teacher

B two. A fourth version was installed for them to review and practice on before

beginning work with their groups. Fig. 79 shows the room layout for the school B trial.
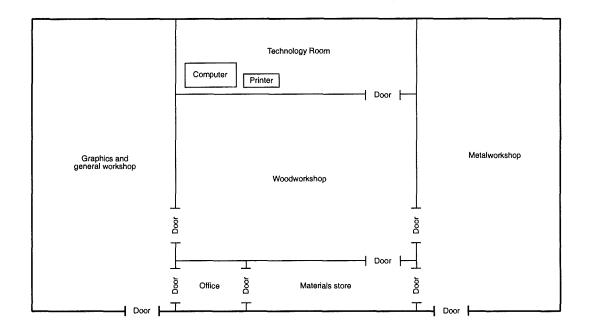
Fig. 79

Trial 1

The first trial took place over the complete Autumn term with three groups of year 9

pupils. Teacher A took one group and Teacher B took two (referred to as B.1 and B,2 in

the courseware data profiles). Teacher B reported some problems with the printer not

working during this trial. He admitted that although he had booted the courseware prior

to the lesson starting he had not always remembered to switch on and test the printer.

After some negotiation it was decided that a good way forward would be to modify the

boot sequence of the courseware for this trial school. A utility was added to the

courseware that generates a unique access code on each new boot. This access code

cannot be viewed on screen but it can be printed and, as a result, the printer status will

be proved. After printing the access code it can be entered via a dialogue box and the courseware will complete its boot sequence. This version is called electronicsDesigner 1.02 and is available on the included CD-ROM. It was used during T2 in this school only.

In line with the methodology model developed for this current research project both participating teachers were interviewed after the first trial was completed. The full interview text is available in appendix 3.2.

T1 Interview Commentary - Teacher A

Teacher A has a good level of experience in teaching electronics at both KS3 and KS4. His previous work in KS3 has been set within framed design and make assignments (DMA), but the electronics component has been taught didactically; essentially type A tasks. However, he recognises the faults with this approach and would prefer to offer a type C approach. In KS4 his work has followed a systems based approach and he has made good capital from the combination of MFA modules and computer based PCB library files. This has been a positive experience with regard to using computers in his teaching. However, he has not had any positive experiences with commercially available software.

He reports 'frustration' with supporting the courseware on one computer and he has invoked strategies to maximise its performance (pupils coming in outside of lesson times to use the courseware). However, he does not report significant problems with waiting for access, more with satisfying his motivated groups.

There were some problems with 'getting back' for pupils who had forgotten to print certain material. This is an issue associated with cluster transition (C1 to C2, C2 to C3, C3 to C4). Material can be reviewed whilst still in the cluster but not once the transition has been made. He gives examples of pupils sharing materials to overcome these occasional problems.

He is generally satisfied with the content and operation of the courseware, but would like to see some differentiated content in the knowledge base. He gives the example of changing the input circuit configuration to illustrate this point. He does not give examples of how this differentiated material might be accessed or 'filtered'.

Teacher A reports very high levels of compliance with specifications 7A and 7B. He is ebullient in his praise for the courseware and has clearly had a very positive experience. However, he does report losing track of 'folder work' during the enthusiastic use of the computer. He has strategies to overcome this issue during the next trial phase.

There are strong indications of a task type match in this trial. Teacher A reports on a wide range of activities taking place with high levels of pupil procedural autonomy. He classifies the courseware as a, "powerful tool" in enabling this teaching approach.

Major Issues - Teacher A

• Indications of a task match

• Shift in pedagogy - less didactic

• Frustrations with using one computer

• Pupil engagement high

• Problems 'getting back'

T1 Interview Commentary - Teacher B

Teacher B is also experienced in using electronics as part of Design and Technology at a range of levels. His reported experience at KS3 is similar to Teacher A, but he does not cite the same didactic limitations to DMAs which use electronics, but does cite limitations to the range of input and output components available for pupils to use mainly through reasons of cost. He gives examples of previous work that has used broader brief frames than for Teacher A, particularly with regard to a choice of process component (transistor or thyristors). Despite this difference his previous KS3 work has still been type A tasks. His work at KS4 and above has been similar to Teacher A and he has made the same good use of modelling using MFA modules and computer based PCB files.

Teacher B reports similar problems in relation to specification 1and 2 compliance. He reports some problems with waiting for access to the computer, but he does not appear to have invoked similar strategies to Teacher A, i.e. pupils returning out of lesson time to use the computer. However, he is supportive of the courseware use because of the extras choices that are made available.

Teacher B reports that some of his pupils appeared to take the shortest route possible when using the courseware as a strategy to glean the essential information from the courseware as fast as possible; often due to high levels of motivation to get the circuit finished and functioning. He reports similar problems to Teacher A with pupils 'getting back' after cluster transitions have been made.

Teacher B found using the courseware to be restrictive during the early phases of the project. In common with his previous work at KS3, he had set broader brief frame than the courseware is designed to support. He freely admits that this was probably due to him not thoroughly reviewing the courseware. He cites successful strategies to refocus pupil projects to fit in with the courseware or to refocus the courseware outcomes to fit in with pupil projects. However, he also reports that occasionally pupils' projects were

refocussed by the courseware itself, by pupils making arbitrary changes to their design intent in order to fit in with the courseware content. So there were strong indications of a task match, but that the brief frame was set too broadly.

Having completed the trial, Teacher B reports that the courseware is supportive and he reports generally high levels of compliance with specifications 7A and 7B. He does not report a similar change in pedagogy away from didactic approaches with electronics as Teacher A. However, there are some indications that Teacher A's approaches to DMAs that use electronics tended to be a little more open ended.

Major Issues - Teacher B

• Indications of a task match

• Brief frame set wider than courseware

• Frustrations with using one computer

• Pupil engagement high
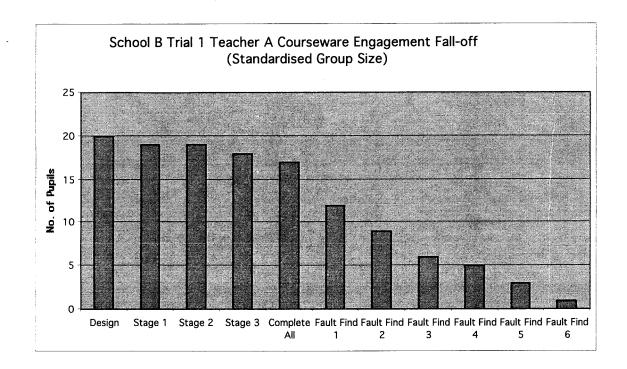
• Problems 'getting back'
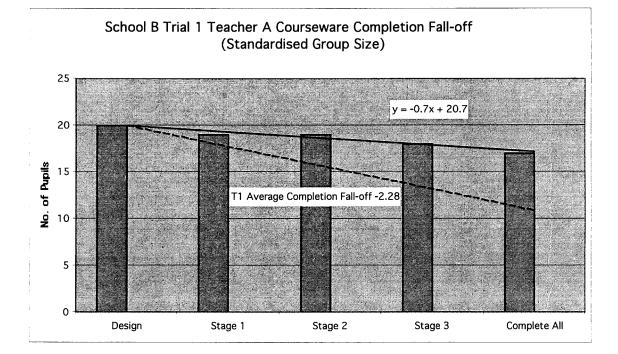
T1 Courseware Data

The level of deviant courseware interaction was low-to-medium. There were higher

levels of deviant interaction for the groups run by Teacher B than for the group run by

Teacher A. In group B.1 the deviancy was focused on half the number of pupils than the

number of deviant acts giving a higher deviancy level. In the two other groups there was

one deviant action per deviant pupil. For the Teacher A group the highest category was

for premature switch- offs (3), whilst there were 2 spurious log-ins and 2 pupils who

had inserted 2 or more spaces in between their name. In the B.1 group there was a

comparatively high number of premature switch-offs (9). In group B.2 the deviancy was

focused on spurious and non-group log-ins. These non-group log-ins were recorded on

Teacher A's courseware but were attached to the deviancy figures for their group (B.2).

	Total Log-ins	Deviancy rate	Deviancy Level
SBT1 TA	20	1.00	0.40
SBT1 TB.1	16	2.00	0.75
SBT1 TB.2	23	1.00	0.57
			0.53
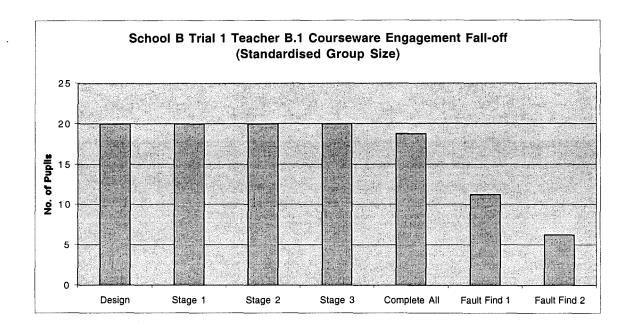
Fig. 80
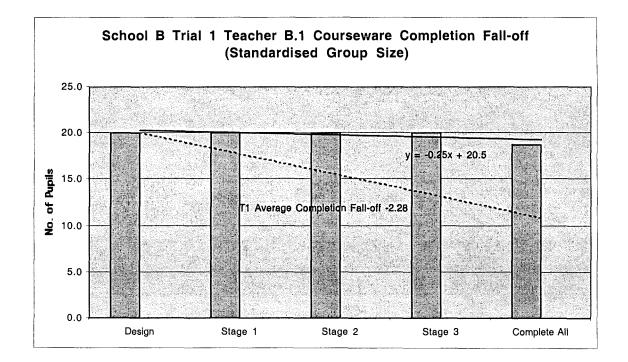
The courseware completion fall-off gradients were much better than average. (T1

average -2.28 fall-off gradient = 54% completion rate). Teacher A shows a slightly

better overall completion fall-off gradient (-0.7). The B.1 group shows a very good fall-

off gradient (-0.25). This is the second best profile for all schools in all trials. However,

the B.2 group, although still well above average is less good than either Teacher A or the

B.1 group (-1.39). These two profiles give an overall completion fall-off gradient of -

0.92 for Teacher B which is well above average.

School B Trial 1 Teacher A Courseware Engagement Fall-off
(Standardised Group Size)

School B Trial 1 Teacher A Courseware Completion Fall-off
(Standardised Group Size)

y = -0.7x + 20.7

T1 Average Completion Fall-off -2.28

Fig. 81

School B Trial 1 Teacher B.1 Courseware Engagement Fall-off (Standardised Group Size)

School B Trial 1 Teacher B.1 Courseware Completion Fall-off (Standardised Group Size)

$y = -0.25x + 20.5$

T1 Average Completion Fall-off -2.28

Fig. 82

School B Trial 1 Teacher B.2 Courseware Engagement Fall-off
(Standardised Group Size)

School B Trial 1 Teacher B.2 Courseware Completion Fall-off
(Standardised Group Size)

$y = -1.3913x + 20.696$

T1 Average Completion Fall-off -2.28

Fig. 83

School B Trial 1 Teacher B (Both Groups) Courseware Engagement Fall-off (Standardised Group Size)

School B Trial 1 Teacher B (Both Groups) Courseware Completion Fall-off (Standardised Group Size)

$y = -0.9231x + 20.615$

T1 Average Completion Fall-off -2.28

Fig. 84

The overall visit concurrency profile for the trial was better than average with a significant pulls towards NS visits and away from CVs. SS visits were generally average but there was a small increase evident in group B.1

Fig. 85

The visit concurrency by cluster showed good levels of congruence with the courseware design intent with overall high levels of NS visits, particularly in the C1 to C2 transition. The profile from Teacher A shows levels of CVs that rise during the C2 phase, overtaking the dominant NS visits, and then tail off again in the C2 to C3 transition. This profile indicates an adopted management strategy by Teacher A. During the C1 to C2 transition the dominant NS visits indicate that pupils completed their PCB before logging back in to the courseware. In the C2 phase the rise in CVs to overtake the NS visits indicate that many pupils have been allowed, or encouraged, to complete the three system changes in a concurrent manner. In the C3 phase CVs fall off again and NS visits again become the dominant feature indicating that the circuit is constructed by the pupils before C3 is accessed. This feature is not congruent with the courseware design intent.
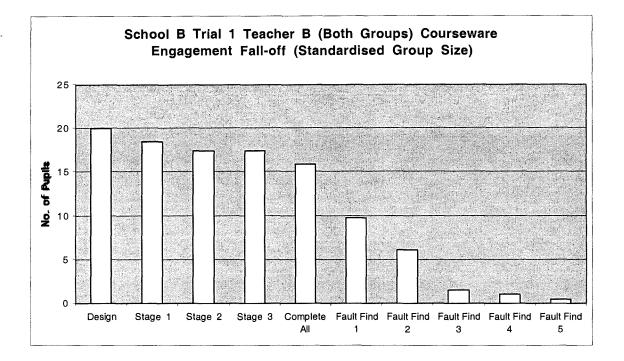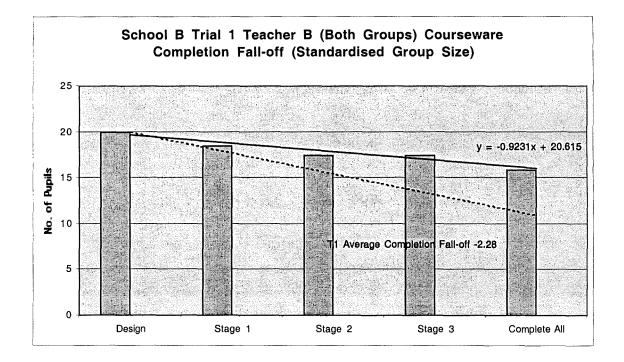

School B Trial 1 Teacher A Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
CV	16%	46%	24%
SS	11%	19%	0%
NS	74%	35%	76%

Fig. 86

This rise and fall in the CV component feature is similar, though less marked in the profiles for the B.1 group.

School B Trial 1 Teacher B.1 Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
CV	13%	25%	27%
SS	13%	19%	13%
NS	75%	56%	60%
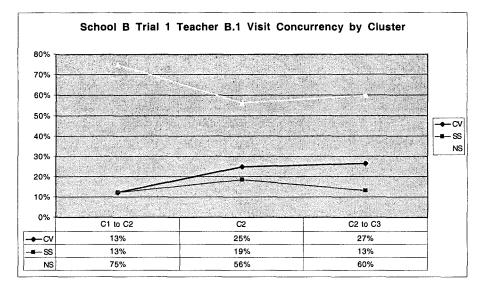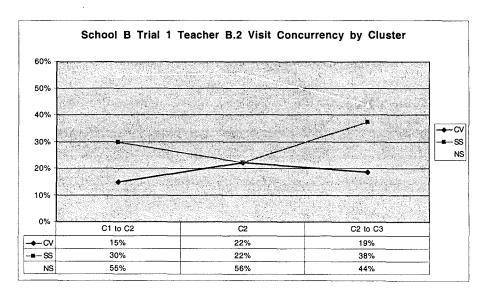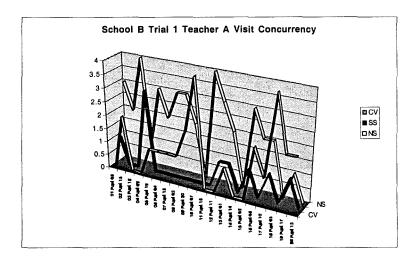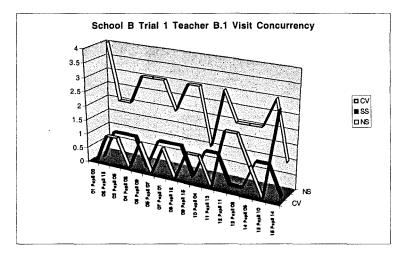
Fig. 87
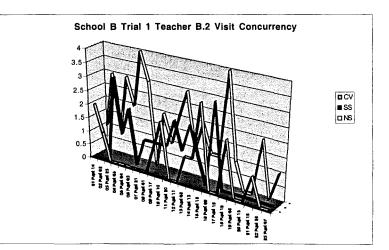
However, the profile for the B.2 group is markedly different. The dominant feature is still for NS visits, with the second most dominant feature being for SS visits. The subordinate feature in this profile is for CVs. There is still a small rise in CVs during the C2 phase, but this time the rise is off-set against the SS visits.

School B Trial 1 Teacher B.2 Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
CV	15%	22%	19%
SS	30%	22%	38%
NS	55%	56%	44%

Fig. 88
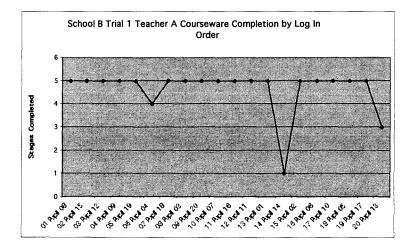
The visit concurrency by pupil log-in for group B.1 shows a clear and largely consistent profile across the entire group. There is a similar, though less clear profile for the Teacher A group. This profile is for a dominant NS visit profile across the group with a rise in CVs towards the end of the group, with the last few pupils to log-in. **There is no clear profile for the B.2 group.**

Fig. 89
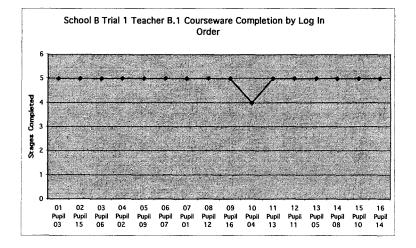
Because of the very shallow courseware completion fall-off gradients the

courseware completion by log-in order shows no clear profile for groups A and B.1.

However, there is a notable fall-off in completion rate for the last few pupils to log

in the B.2 group, with no correlation between this profile and the visit concurrency

by log-in order.
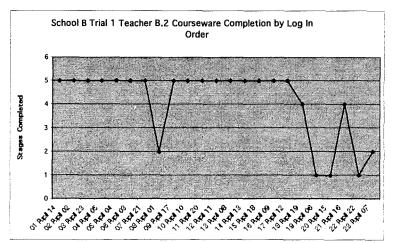
Fig. 90

The systems built profile for Teacher A is close to average for 3 of the 5 inputs.

However, although they were generally less popular across all trials, the tremble switch

and wire loop are under represented.
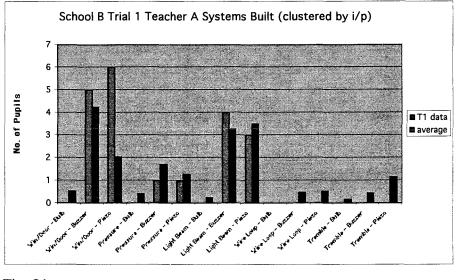
Fig. 91

The Systems built profiles for Teacher B both have marked clumps around the

win/door switch and the pressure pad, both of which, when combined with a

buzzer, are over twice the trial average.
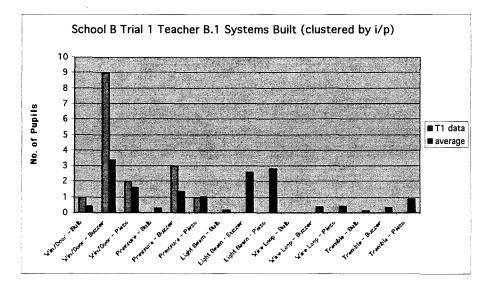
Fig. 92
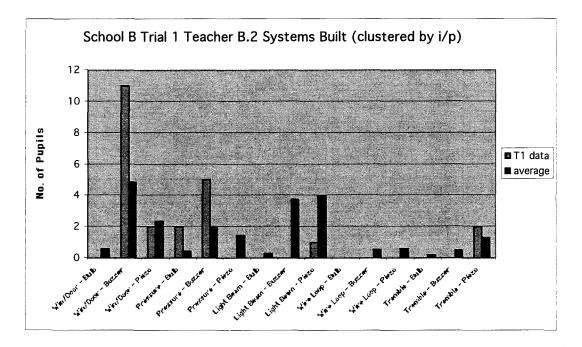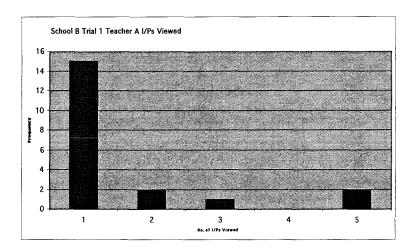
Fig. 93
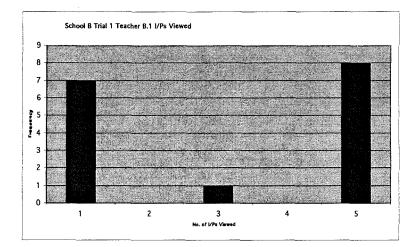
The systems modification profiles and design visit profiles indicate low levels of heuristic interaction with the courseware. In group A only one pupil made any changes to their system. This pupil changed the input from a wire loop, to a light-beam and then to a win/door switch on three successive visits. However. He only made one visit to the input realm and, hence, never accessed the information regarding these two new input circuits. In group B.1 one pupil changed from a win/door switch to a wire loop and then back again on two successive visits, perhaps representing some consideration of the application context for the system. In group B.2 there were no instances of system modification.
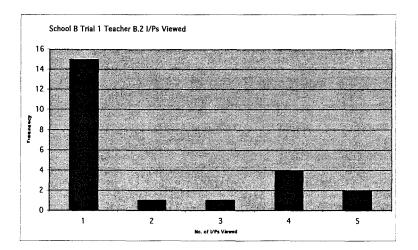
SBT1	Change Possibility	System Changes	
Teacher A	48	2	4%
Teacher B.1	56	2	4%
Teacher B.2	56	0	0%

Fig. 94
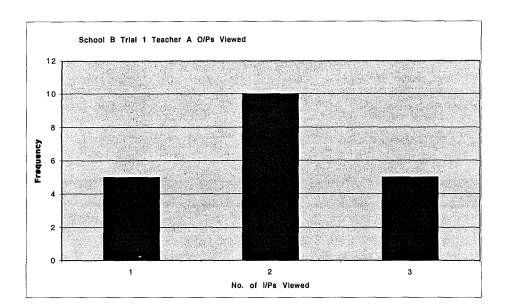
The design visit profiles show a low level of compatibility with heuristic

approaches to the use of C1, all the profile curves being the inverse of a compatible

distribution except for the profile for teacher A outputs viewed.

Fig. 95

School B Trial 1 Teacher A O/Ps Viewed

School B Trial 1 Teacher B.1 O/Ps Viewed

School B Trial 1 Teacher B.2 O/Ps Viewed

Fig. 96

T1 Courseware Data Commentary
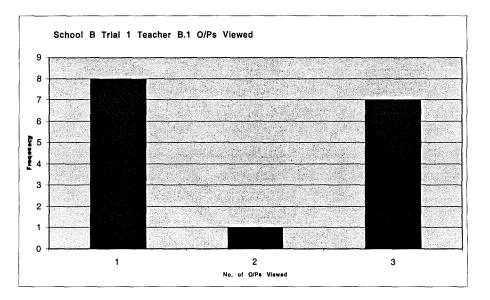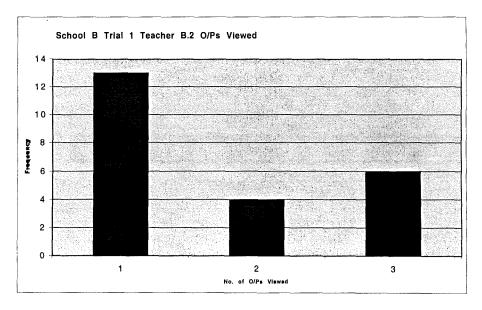
The courseware data indicate an overall trial performance that is well above average in a range of aspects; the combined profiles representing the best overall performance for a complete school for any trial. There are some notable differences between the performance of groups A and B.1 compared with group B.2. Groups A and B.1 outperform group B.2 in a range of common profiles across the data sets.

The level of courseware deviant interaction is low to medium. Teacher A's group has a lower level of deviant interaction than both of Teacher B's groups indicating a slightly higher level of courseware management by Teacher A. There is a significant correlation between the total log-in figures for the three groups shown in the deviant interaction table and the courseware completion fall-off gradients.

Group	Total Log-ins	Fall-off Gradient
B.1	16	-0.25
A	20	-0.7
B.2	23	-1.39

Fig. 97

As the group sizes rise the courseware completion fall-off gradients become steeper. There is no immediately evident mathematical relationship between the two data sets, nor perhaps should one be sought as the situation represented by the learning milieu is a complex and dynamic construct with many variables. However, these data indicate that the group size is a significant component of the courseware completion fall-off gradient in this learning milieu, where a significant factor is the computer numbers available. When the courseware completion by log-in profiles are considered it appears that, in

this learning milieu, a saturation point is reached at somewhere between 16 and 20 pupils. Any more than this seems to have a detrimental effect on the completion profiles and fall-off gradients.

The various visit concurrency profiles indicate that both teachers in this trial have managed the courseware use by their groups. The overall visit concurrency profiles were better than average and there was a notable pull towards NS visits and away from CVs by all groups. These profiles are more congruent than the average with the courseware design intent. In groups A and B.1 the visit concurrency by pupil log-in indicates that the relative proportions of CV, NS and SS visits were well maintained throughout the groups, which supports the indications of teacher management in the pupil use of the courseware (This is slightly less well defined in group A.). In both of these profiles there are rises in the CV component of the profile for the last few students to log-in. In this region the profiles are not completely constructed from CVs as there are still some NS and SS visits evident. However, the CV rate of the last few pupils has risen in comparison to the rest of the group, again indicating teacher management. Pupils have either been allowed, or encouraged, to increase their CV rate in order to complete the courseware in the given time-frame for the project.

It is in the visit concurrency by cluster that teacher management strategies become increasingly evident, particularly with regard to Teacher A. From the group A profile it is evident that Teacher A has worked with the courseware design intent in C1 and the C1 to C2 transition. The proportion of NS visits on the C1 to C2 transition phase is of a high order (74%), whilst CVs are very low (16%). This indicates that the majority of pupils completed their PCBs before making the C1 to C2 transition, which is congruent with the courseware design intent. However, in the C2 phase there is a sharp rise in the CV component of this profile with a commensurate fall in the NS component. This

deviates from the courseware design intent, but indicates that Teacher A is encouraging

his pupils to complete the C2 visits (input, process, output stages) in a more concurrent

manner. There is a notable fall in the CV component at the C2 to C3 transition phase

with a commensurate rise in the NS component, which further supports this indication

of teacher invoked strategies to manage pupils' interaction with the courseware.

Essentially Teacher A has worked with the courseware design intent throughout the

project, but has modified it during the C2 phase to enable the courseware to be more

efficient in this learning milieu. This teacher invoked management strategy is also

evident in the B.1 group, but is less clearly defined. However, the rise and fall in CVs

associated with a fall and rise in NS visits as the C2 phase is passed through is clearly

evident.

The visit concurrency by cluster profile for the B.2 group is more congruent with the

courseware design intent, i.e. dominant NS visits, sub-dominant SS visits and a small

component of CVs. However, the completion fall-off gradient for this group is the worst

of the three, indicating that the courseware design intent is not matched to this learning

milieu with regard to C2. These data sets and teacher invoked management strategies

indicate that the courseware would be more effective, and be more compliant with the

teacher's practicality ethic, if C2 could be completed in one visit instead of the

minimum three visits in a learning milieu of this type.

The systems built profiles are markedly different for the two participating teachers, but

not for the two groups run by teacher B. Group A's profile is close to average although

the less popular wire loop and tremble switch inputs have 'no takers' in this group. In

both group B.1 and B.2 there is a marked clump around the win/door switch and the

pressure mat. From the T1 interviews there are indications that these differences in the

profiles have links to the pedagogical approach adopted by each teacher and the

closeness of the task match.

Teacher A reports that he has been far less didactic in his teaching of the electronics component of the DMA that he has set, than he would previously have been. He reports that the courseware has enabled him to pass significant amounts of control over the activities across to his pupils, enabling high levels of pupil procedural autonomy. This congruence between the teacher's project aims and the courseware design intent will be concomitant with a largely average spread of systems built in this profile. Teacher B indicates that, in common with his previous work, the brief frame that he set at the start of the DMA was broader than the courseware design intent. He reports difficulties with matching pupil design propositions with the courseware content and he invoked strategies to overcome this mismatch, which mainly involved his positive intervention in enabling pupils to adapt the courseware content to fit their design propositions. This congruence between the task type and the courseware design intent, but lesser congruence between the two brief frames, has caused teacher B to intervene in pupils interaction with the courseware causing a clump in the systems built profile and also highlights a possible loss of compliance between the courseware and the teacher's practicality ethic.

T1 Significant Features

1. One computer (A&B)

2. Group size saturation point(A&B)

2. Task Match (A&B)

3. Brief frame too wide (B)

4. Teacher intervention (B)

5. Teacher Management of courseware (A&B)

6. Teacher invoked CV strategy for C2 (A)

7. Less didactic Teaching (A)

8. Systems Built Narrow (B)

9. 'Getting back' (A& B)

10. Overall performance high (A& B)

11. Indications of compliance with teachers practicality ethic (A)

12. Indications of non-compliance with teachers practicality ethic (B)

T1 Concomitant Features

Teacher A

Fig. 98

Teacher B

```
┌─────────────────┐           ┌──────────────┐           ┌──────────────────────┐
│ Task Match      │           │ One Computer │           │ Problems "Getting Back"│
│ (Frame Too Wide)│           └──────────────┘           └──────────────────────┘
└─────────────────┘                 │    │
        │                           ▼    ▼
        ▼                  ┌──────────────────┐  ┌──────────────────┐
┌─────────────────┐        │ Teacher Management│  │ Group Size       │
│ Teacher Intervention     │ of Courseware    │  │ Saturation Point │
└─────────────────┘        └──────────────────┘  └──────────────────┘
        │
        ▼
┌─────────────────┐
│ Systems Built   │◄──────────────────────────
│ Profile Narrow  │
└─────────────────┘
        │
        ▼
┌───────────────────────┐
│ High overall performance│
│ (Lower than Teacher A) │
└───────────────────────┘
        │
        ▼
┌───────────────────────┐
│ Teacher's Practicality │◄──────────────────
│ Ethic Less Compliance  │◄──────────────────
└───────────────────────┘
```
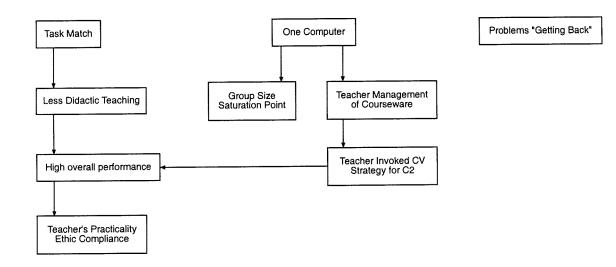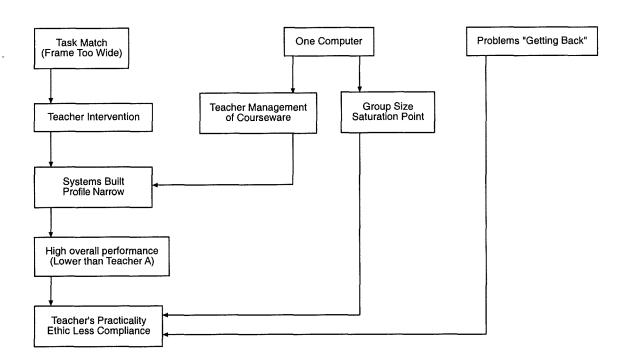
Fig. 99

Trial 2

Trial 2 took place with both of these courseware adopting teachers. In T2 both teachers took one group of year 9 pupils; Teacher A having a group of 16 and Teacher B a group of 18. T2 took place during the following Spring term, in the same rooms and with the same computer system. During this trial electronics designer 1.02, with the access code printer test utility added, was used by both teachers. During this trial no problems were reported with the printer. However, Teacher B reported problems with a corrupted first orientation activity page in his courseware during week 3 of the trial. This had apparently been caused by a pupil accessing the authoring tools in hyperCard. It was not clear how this could have happened as all menu bars and tools palettes had been hidden and the user level had been kept as low as possible. This problem did occur for one other teacher in a different trial in a different school. It can only be surmised that a set of circumstances that are difficult to identify and reproduce conspired to corrupt this

courseware page. It may be that premature switch-off at a particular point is a significant factor in this page corruption. The courseware was repaired in the period between lessons 3 and 4. This problem caused a portion of the lesson in week 3 to be unsupported by the courseware.

In line with the project methodology model for this current research project both participating teachers were interviewed after T2 was completed using the adopters' interview schedule. The full interview text is available in appendix 3.2.

T2 Interview Commentary - Teacher A

From the T2 interview it is evident that Teacher A is still highly satisfied with the courseware. He has learned from the experience of the first trial and invoked a number of strategies to overcome any potential mismatch between the courseware design intent and his learning milieu.

He reports that he has carefully managed the use of the courseware to avoid deviant interactions.

He has set up activities to run concurrently with the courseware interactions; a situation that is congruent with the courseware design intent. He recognises that the major 'bottle-neck' is C1, but has engaged his pupils in designing activities whilst the C1 visits are completed.

During this interview he does not report the T1 problems of pupils not being able to 'get back' to review content from clusters that have been completed. However, it is evident that this problem is still there, but he has overcome it by pupils sharing information when necessary.

From the interview transcript it is clear that there is a task type match and he is positive about the courseware's ability to support this task type. He again reports that this has

enabled him to take a less didactic teaching approach to the electronics component of the DMA and that his pupils are working with high levels of procedural autonomy. He fully subscribes to the view that pupil procedural autonomy is an important aspect of Design and Technology capability. From his previous experience it is evident that he has used learning materials to support this level of autonomy at KS4 and above (MFA modules and computer PCB libraries). He is pleased that the courseware now enables him to take this teaching approach at KS3.

Teacher A sees this courseware as a very positive asset and is again ebullient in his praise for it. He would like to use this approach in other aspects of his teaching and is able to cite some examples of where it could be deployed.

From this second trial it appears that there is a high level of congruence with the courseware design intent and the Teacher A's aims. He has modified his approach in light of his T1 experience to overcome any previous difficulties, which indicates a high level of compliance with his practicality ethic.

Major Issues - Teacher A

• Task Match

• Strategies to overcome difficulties with using one computer

• 'getting Back'

• High congruence between courseware design intent and teachers aims

• Compliance with teacher's practicality ethic

T2 Interview Commentary - Teacher B

From the T2 interview there are indications that Teacher B has modified his teaching strategies and approaches in light of his T1 experience. In common with Teacher A he has also set up activities to run in parallel with the courseware interactions. He sees this as a positive development as the activities, 'fit together well'. However, he maintains that his pupils need to complete the electronics elements before they can do any meaningful design work. There are no indications that parallel activities were set up to overcome problems with access to the courseware in particular phases of the project. Teacher B does not report the same bottle-neck in C1 reported by Teacher A, but does say that pupils waiting for access is a problem throughout the whole project. He describes a situation where pupils make mistakes logging-in, or miss courseware elements, because they are too rushed when using the computer. He suggests that 3 computers would be necessary to integrate the courseware satisfactorily into his learning milieu.

Despite the reported difficulties with infrastructure, Teacher B still reports high levels of compliance with specifications 7A and 7B. However, in common with T1, there are indications that although there is a task type match, there is a mismatch netween the courseware's and the teacher's framing of the project. There are strong indications that Teacher B has modified his teaching approach to bring the frames closer together. He reports a consequent improvement in the quality of outcomes and the success rate of pupils, but he is still uncomfortable working with a tighter brief frame than he would normally do. He would prefer the courseware to supply more generic information with regard to the input componentry. The tremble switch has a generic description with an application context indicated by a picture. He reports that the picture can be a seductive element for his pupils and can lead to arbitrary design changes. The micro-switch and reed-switch are given a contextual description with supporting pictures. He feels that this contextual description is too specific and can lead to confusion with his pupils who are seeking alternative applications for these devices. Teacher B was the only trial

participant in all schools to report on these difficulties with information presentation and its effects on pupils subsequent actions. Moreover, he was the only participant who questioned the tightness of the courseware brief frame. There is an evident relationship between the range and number of significant design decisions in the project and the looseness of the brief frame. However, these responses indicate that there is also be a relationship between the specificity of the application context for the componentry and the looseness of the brief frame.

Teacher B sees pupil procedural autonomy as a fundamental aspect of the subject. He describes teaching approaches that he uses to enable pupils to take control of their projects and he recognises the courseware's ability to support him in doing this. However, although he reports on high levels of pupil procedural autonomy, motivation and success, the apparent mismatch between the courseware's brief frame and his preferred teaching approach, coupled with his perception of a lack of sufficient computing infrastructure indicate a potential fall in congruence with the courseware design intent and Teacher B's practicality ethic.

Major Issues

• Task match

• Frame mismatch

• Some modifications of teaching approach to achieve frame match

• Frustrations with using one computer

• High congruence between courseware design intent and teacher's aims

• Indications of a loss of complicance with the teacher's practicality ethic.

T2 Courseware Data
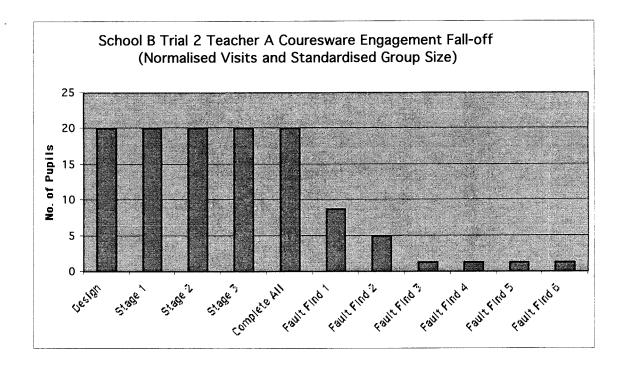
The level of deviant courseware interaction was again low-to-medium for both groups. Again there were higher levels of deviant interaction for Teacher B than for Teacher A indicating less careful supervision of the courseware by Teacher B. However, both sets of figures show a small improvement in these levels for both teachers with a similar profile of deviant interaction types.

	Total Log-ins	Deviancy rate	Deviancy Level
SBT2 TA	16	1.00	0.38
SBT2 TB	18	1.25	0.56
			0.47

Fig. 100

The courseware completion fall-off gradients for Teacher A were perfect, showing full congruence with the courseware design intent. The courseware completion profile fall-of gradient was 0 showing 100% courseware completion. The courseware engagement profile showed full completion with a rapid fall-off in the fault finding stages. **The profiles for Teacher B showed a marked decline in performance from T1.** The courseware completion fall-off gradient (-2.56) was slightly below average (-2.28) and much steeper than for this teacher in T1 (-0.9). The Courseware engagement profile shows a fall-off to the courseware completion stage, with the steepest fall-off gradient between C1 and C2. Only 56% of pupils made the transistion into C2 in this group.

School B Trial 2 Teacher A Couresware Engagement Fall-off
(Normalised Visits and Standardised Group Size)

School B Trial 2 Teacher A Courseware Completion Fall-off
(Normailised Visits and Standardised Group Size

T1 Performance -0.7

T1 Average Completion Fall-off -2.28

Fig. 101

School B Trial 2 Teacher B Courseware Engagement Fall-off
(Standardised Group Size)

School B Trial 2 Teacher B Courseware Completion Fall-off
(Standardised Group Size)

T1 Performance -0.9

T1 Average Completion Fall-off -2.28

$y = -2.56x + 19.44$

Fig. 102

The visit concurrency profiles so a shift in opposite directions for the two teachers.
The profile for Teacher A shows a move back towards the average with a small fall in NS visits and a comensurate increase in CVs. The profile for Teacher B shows an increase in the trend noted in T1 for both teachers, with a continued pull towards NS visits and a further fall in CVs. This trend pulls the profile closer towards the courseware design intent for Teacher B.

Fig. 103
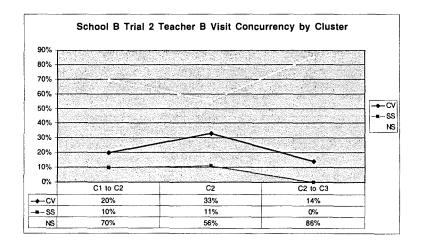
The visit concurrency by cluster profiles show an increase in the level of the T1 courseware management strategy adopted by Teacher A. The profile for Teacher A has the same hierarchies and relationships between the three visit components, but there is an amplification of the courseware management strategy relating to congruence with the courseware design intent in the C1 to C2 and C2 to C3 transition phases, with an increase in CVs, and consequent loss of congruence, during C2.

Fig. 104
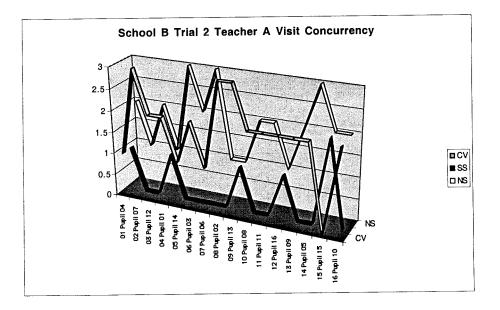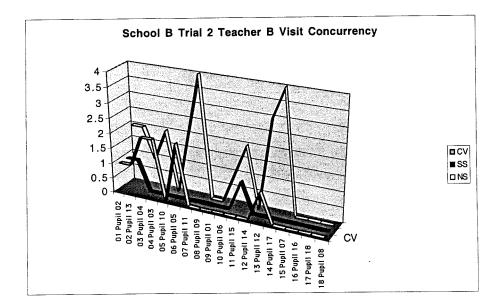
The profiles for Teacher B show similar relationships between the three visit components, but with less marked trends. These relationships were not evident for Teacher B in T1. The profile indicates that Teacher B has adopted the same courseware management strategy as Teacher A but to a much lesser extent.

Fig. 105
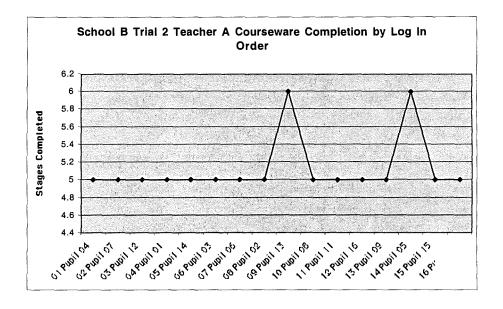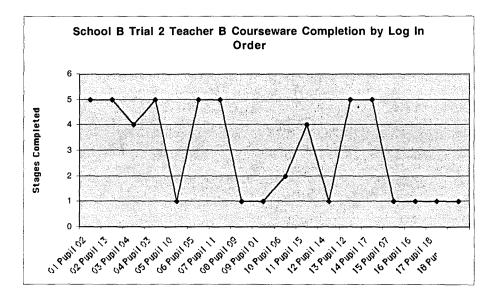
The visit concurrency by pupil log-in for Teacher A shows a clear and largely consistent profile across the entire group. This profile is similar to that noted in T1 but the level of CVs has increased across the entire group in line with the courseware management strategy adopted by Teacher A. There is no clear profile for the Teacher B group although there is a notable fall-off in all visit types for the last few pupils to log in to the courseware.

Fig. 106

Because of the horizontal courseware completion fall-off gradient for the Teacher A group there is no possible relationshhip between courseware completion and log-in order to indicate. The curve shown is not normalised as it shows that two pupils made 6 visits rather than the minimum 5 to complete the courseware. The courseware completion by log-in order for the Teacher B group shows no clear profile, but there is a notable high level of completion for the first few pupils to log-in and a low level of completion for the last few pupils to log-in.

Fig. 107

The systems built profile for Teacher A is again close to average, but with a notable

increase in wire-loop and tremble switch inputs and no light-beam inputs.

School B Trial 2 Teacher A Systems Built (clustered by i/p)
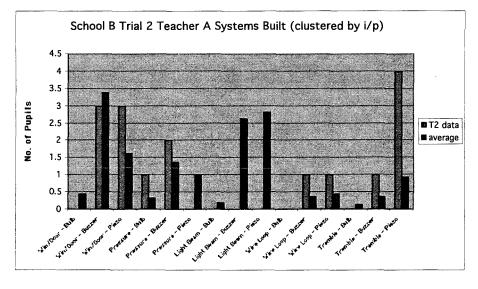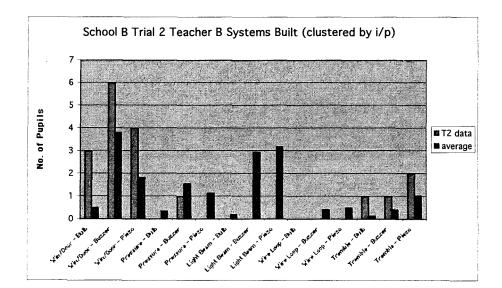
Fig. 108

The profile for Teacher B shows a similar clump around the win/door switch as in

T1. However, this is less marked and there is a similar increase in wire-loop and tremble

switch inputs and no light-beam inputs as for Teacher A.
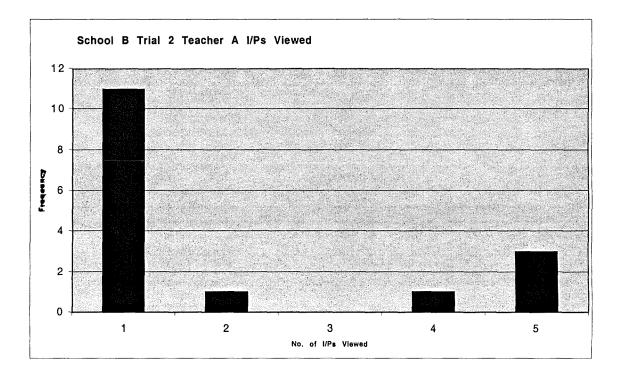
School B Trial 2 Teacher B Systems Built (clustered by i/p)

Fig. 109

The systems modification profiles and design visit profiles indicate low levels of heuristic interaction with the courseware. In group A two pupils made one change each to their output circuits. One from a buzzer to a piezo sounder and one from a bulb to a buzzer (both possible improvements to system performance). In group B, one pupil changed the input circuit from a light beam to a win/door switch (a possible improvement to the system for its application context, but this was the only instance of a light-beam input in the whole trial, which may indicate other motivating factors).

SBT2	Change Possibility	System Changes	
Teacher A	50	2	4%
Teacher B	28	1	4%

Fig. 110

The design visit profiles show a low level of compatability with heurisitic approaches to the use of C1, all the profile curves being the inverse of a compatible distribution.

Fig. 111

School B Trial 2 Teacher A O/Ps Viewed

School B Trial 2 Teacher B O/Ps Viewed

Fig. 112

T2 Courseware Data Commentary
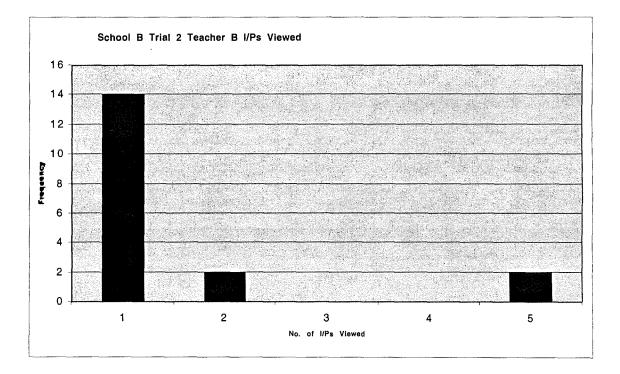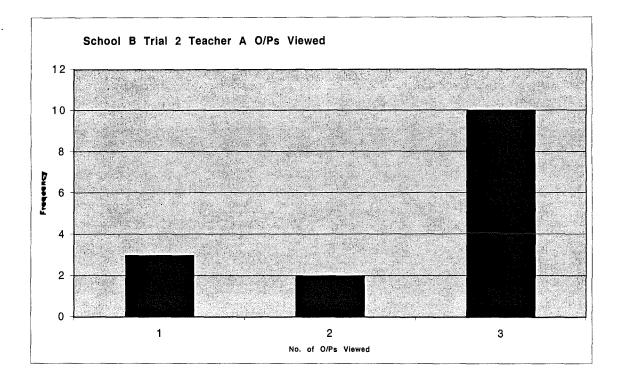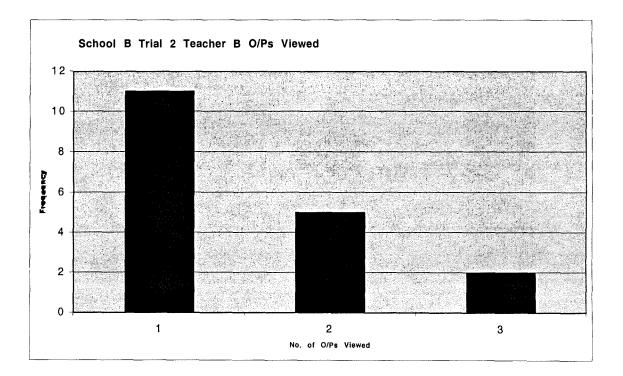
The courseware data indicate a change in performance across a range of aspects for both participating teachers. However, these changes show a rise in performance for Teacher A and a fall in Performace for Teacher B.

There were no significant changes to the levels of deviant courseware interaction save for a slight overall improvement for both teachers. Both groups were of similar size (16 and 18), hence, the noted saturation point from T1 in this learning milieu is not a factor. The teacher B group again shows a higher level of deviant interaction with the courseware which indicates a possible lower level of courseware supervision by Teacher B.

The various visit concurrency profiles again indicate teacher managment of the courseware use. However, in the overall profiles there are opposite trends evident. Teacher A's overall profile shows a clear retreat towards the average, whilst Teacher B's overall profile shows a continued trend towards congruence with the courseware design intent. These trends are at conflict with the courseware completion fall-off gradients indicating that visit type congruence with the courseware design intent is not concomitant with shallow completion fall-off gradients in this learning milieu. Further insight is provided by the visit concurrency by cluster profiles. These show that Teacher A has again encouraged a CV strategy during C2, with congruent visit behaviour in C1 and C3, and that his use of this strategy has been applied even more rigorously. If this adopted strategy is compared to the 100% courseware completion rate it is evident that concurrent completion of C2 is a significant factor in overall courseware completion. It is also notable that this profile is now present with the Teacher B group, but to a far lesser extent. This may indicate that Teacher B has been influenced by Teacher A or that a critical process with associated courseware modification need is emerging.

The systems built profiles are similar for both teachers compared to T1 and have the same significant features. However, in T2 the profiles of both teachers are closer to the average except for the use of the light-beam input. There are no clear indications from the interviews why this input has not been used nor why the one instance of a pupil choosing it was changed during their courseware interaction. It may be that this is simply attributable to a lack of availability of these components (the LDR is the most expensive component) or that the difficulties with getting this input circuit to work reliably have been passed on to the pupils.

The most significant indicator of why the overall performance profiles for both teachers should be at variance in their trends is the task and frame match for Teacher A and the task match but frame mismatch for Teacher B. It appears that this essentially pedagogical factor, relating to congruence between the courseware design intent and the teachers' aims, has caused Teacher A to modify his approach to ensure that the courseware is successfully integrated into his learning milieu. Teacher B has also modified his approach, but is less comfortable than Teacher A in doing this. Integrating the courseware into Teacher A's learning milieu is compliant with his practicality ethic as it enables him to achieve his aims. He has not been able to achieve this level of pupil procedural autonomy at KS3 before the courseware was available to him. Pupil procedural autonomy is also important to Teacher B and he recognises the contribution that the courseware can make in achieving it. However, he prefers a teaching approach that is more open-ended than the courseware allows. Achieving this open-endedness relies upon him making regular inteventions in his pupils interactions with the courseware, which is costly in terms of his own time. He feels that the courseware limits his ability to teach in his preferred manner, which leads to a loss of compliance with his practicality ethic with the associated fall in indicated courseware performance.

T2 Significant Features

1. One computer (A & B)

2. Task match (A & B)

3. Frame mismatch (B)

4. Pupils waiting for access (B)

5. Teacher intervention (B)

6. Pupils sharing information (A)

7. Teacher management of courseware (A & B)

8. CV strategy for C2 (A & B)

9. Rise in overall performance (A)

10. Fall in overall performance (B)

11. Compliance with teachers practicality ethic (A)

12. Non-compliance with teachers practicality ethic (B)

T2 Concomitant Features

Teacher A

Fig. 113

Teacher B

Fig. 114
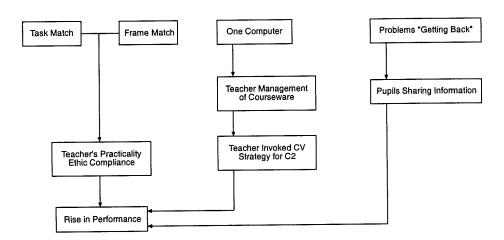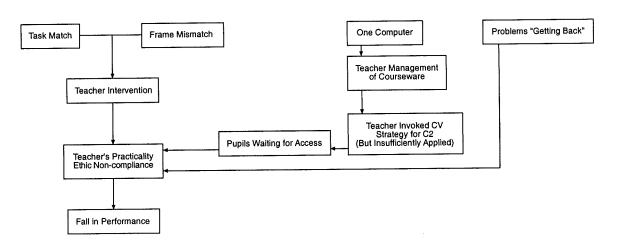
Chapter 4 - The Case Studies

Section 3 - School C

*The school is situated on the edge of [East London Town] and draws from
within and outside the borough including some areas of considerable social
disadvantage. The school has to cope with high levels of mobility. The
problems created in the area by unclosed waiting lists are being resolved by
the LEA in partnership with schools. The full ability range is present within
the school although the great majority of entrants have low levels of
attainment on entry. There are 340 boys and 388 girls in the school. The
school contains pupils from different ethnic, religious and cultural
backgrounds. The number of refugees in the school is growing.*

(OFSTED)

School C is a single site school situated in a residential area, quite close to a large East

London town and the North Circular road. The main school building is Victorian. A

collection of extensions and outbuildings have been added as the local suburban

population grew from the 1930s onwards. The school is relatively small with regard to

pupil numbers; the smallest in the range of trial participants. It had recently benefited

from Technology Schools Initiative (TSI) funding.

The Design and Technology Department

The Design and Technology department is situated in the main body of the school in an

extension to the main building. At the time of the trial, food and textiles were not

integrated in to the Design and Technology department. They were provided by the

school, but were separately located and managed. The physical geography gives a

definite feeling of a department. There is one well signed entrance to a main corridor

that contains displays of Design and Technology graphics and project work. The workshops and studios are all accessed from this main corridor. There are two Design and Technology workshops, which are both equipped for multi-material work, a networked computer room and a graphics studio. Design and Technology had benefited considerably from the TSI funds. This money had been spent on a network of ten Macintosh Quadra computers with laser printer and scanner, two CNC mills and general refurbishment of the rooms.

At the time of the trial the department was staffed by four full-time members of staff with a variety of experience and expertise. There was one head of department and three main-scale teachers. At Key Stage 3 all staff taught in the three subject areas offered - resistant materials, systems and control and graphics. In Key Stage 4 there were two GCSE groups. One in resistant materials and one in graphics. There were no 'A' level students. There was one full-time technician with a typical range of workshop responsibilities. He was also responsible for much of the pupil support during CAD/CAM project work. Fig 115 shows a diagram of the department structure, expertise and responsibilities. It also indicates which staff took part in the trials.
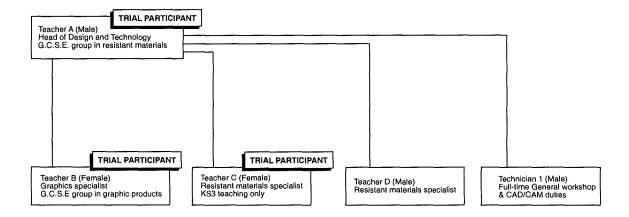
Fig. 115

Background to the Trials

As Head of Department Teacher A had been willing to participate in the trial and he was
the initial contact in the school. A variety of electronics projects had been taught by both
himself and Teachers B and C. Teacher D was less familiar with this medium. Teacher A
was keen to develop this area of the curriculum and to capitalise on the IT infrastructure
that had been made available as part of the TSI funds. Teachers A, B and C would all be
taking year 9 groups during the trial period. Teacher A encouraged Teachers B and C to
become involved. The courseware was demonstrated to them and they readily agreed.
The following table details the trial groups.
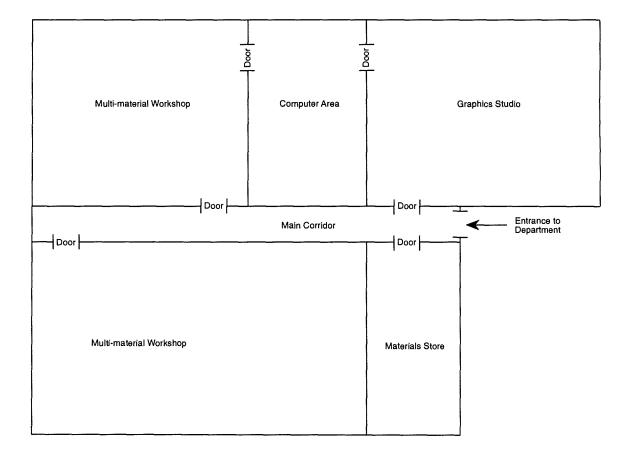
Autumn Term		Groups
T1	Teacher A	1
T1	Teacher B	1
Spring Term		
T2	Teacher A	2
T1	Teacher C	4

Fig. 116

The setting for the trial was in the two multi-material workshops, with the courseware
installed on the network of Macintosh Quadra machines in the computer area. These
computers were well used by both teachers and pupils in their Design and Technology
project work. CAD/CAM projects had been integrated into normal provision in KS3 and
4 using Roland CAM3 CNC mills and their proprietary CAM software. There was a
variety of other generic packages installed on the computers and pupils appeared to
make regular use of them in their various projects in both resistant materials and
graphics. The computer area is situated between one of the workshops and the graphics
studio and is accessible from both of them. To gain access from the second workshop it
is necessary to cross the corridor and enter via either the workshop or the graphics
studio. The computer area is generally treated as an open access room. It is often used

by pupils from a number of different classes at the same time. It is relatively easy to supervise on a macro level as it is surrounded by glass partitions. However, the teacher must be sited in the area to undertake micro level supervision.

The courseware was installed onto eight computers for the first trial phase and ten for the second. A separate folder was set up for each teacher and placed in a location of their choice. A unique version of the courseware was installed on each of the eight machines for each teacher and named accordingly. Fig 117 shows the room layout for the school C trial.

Fig. 117

Trail 1

The first trial lasted the whole of the Autumn Term for Teachers A and B. Teacher C undertook trial 1 throught the following Spring Term. No problems were reported with any of the machines during any of the trial phases. However, when the courseware was analysed after collection there were a number of copies that had been corrupted and rendered inoperable. Because of the size of this trial and the number of computers available for pupils to use in an open access area, the group results were combined to form singular data sets referring to each teacher (3 for T1 and 1 for T2) rather than by individual group (6 for T1 and 2 for T2). This enabled a rationalisation of the data analysis, with the associated brevity in reporting, whilst still maintaining integrity of the data sets.

In line with the methodology model developed for this current research project all three participating teachers were interviewed after the first trial period was completed. The interview transcripts are available in appendix 3.3.

T1 Interview Commentary - Teacher A

Teacher A has a good level of experience and expertise in electronics. He has been involved in a range of work from 11 to 16. At KS4 this has been in supporting major projects for G.C.S.E. Technology. At KS3 He has been involved in a range of projects, including a Standard Attainment Test (SAT), which was very similar in nature to the courseware task. However, although these tasks have been of type C, his general experience has been with projects that have given less choice to pupils. He gives three reasons for this restriction: cost, pupil ability and teacher experience. His previous teaching approach has been to, "prime them up" with theoretical knowledge before the design and make assignment (DMA) took place. This is often referred to as a resource/ capability delivery model where theory and practice become somewhat separated. This teaching approach was not implicit in the National Curriculum document operating at

that time, but was in many of the G.C.S.E. suggested delivery models. This approach

would be concomitant with restrictions in pupil choice, by a narrow task frame, if pupil

ability and staff expertise were in question. After using the courseware was conscious of

the courseware's ability to guide his pupils through the design process and to support a

type C task with a broader frame than he has previously experienced. He cites the ability

of the courseware to offer, "choice in a structured way", which he sees as a positive

development. Hence, there are strong indications of both a task and frame match. This

indication is further reinforced by his conjecture concerning the inability of a

completely open, "virtual laboratory" to be successful in his learning milieu.

There are instances in the interview indicating that Teacher A is still unsure of his

pupils' theoretical knowledge, but he does assert that certain aspects have definitely

been assimilated into his pupils' understanding. This begins to indicate a possible

mismatch, or tension, between the courseware design intent and Teacher A's preferred

teaching approach. He has concerns of a potential loss of control of his pupils in his

learning milieu and cites instances of pupils spending too long using the courseware

rather than progressing with the project and of pupils bringing their own agenda to the

lessons, potentially causing the teacher to be in a 'fire-fighting' situation.

Teacher A reports a generally high level of compliance with specification 7A and 7B.

However, he does have concerns about 'getting back' after a cluster transition is made.

He is supportive of the courseware design intent with respect to cluster transition and

relates this process as a positive attribute to his learning milieu. He suggests that a

teacher version of the courseware could be devised and used to supply missing

information to pupils and would, hence, overcome the transition difficulties.

Teacher A reports no problems with computer access other than his pupils spending too

long using them, which may indicate some concomitance between these factors in this

learning milieu. He also flags that physical changes were made to the learning

environment to satisfy another teacher, i.e. some computers were moved into a

workshop, so making them an integral part of the working environment and limiting the numbers available. This change actually took place during T2.

Major Issues

• Indications of a task match

• Indications of a frame match

• Indications of a teaching approach mismatch (Resource/Capability - Framed Task)

• Pupils spending too long using the computers

• Problems getting back

• Less control

• Indications of compliance with teacher's practicality ethic

T1 Interview Commentary - Teacher B

Teacher A is a recently qualified, mature entrant who has a background in graphic design. This was her second year in post in her first teaching position. She describes her expertise in electronics as, "growing rather than confident". Her previous experience in electronics has all been at KS3. The projects described are all type A tasks and, as such, are at variance with the work described by Teacher A. However, this is likely to be a result of her recent appointment. Most of the work described by Teacher A would have taken place before Teacher B joined the school. Teacher A had already expressed an opinion that brief frames are limited by a teacher's experience and expertise, which may lend insight into why Teacher B has been given, or advised to undertake, these projects with her pupils. Teacher B reports some positive aspects with using the courseware, but overall her experience appears to have been negative. She attributes much of this to the

character and make-up of the trial group, which she describes as exceptionally difficult

for this school.

In view of her perceptions of her group she invoked an access limitation strategy,

whereby she limited the pupils' use of the courseware, and the construction of their

electronic circuits, to small groups of 3 or 4. The remainder of the group were engaged

in other miscellaneous folder work; they were essentially put in a 'holding pattern'

whilst waiting for their turn to complete the electronics part of the project. It is unclear

from the interview whether this was a result of early experiences in the project or

whether this strategy had been invoked from the outset, only that this level of freedom

was the maximum at which she felt comfortable and in control.

Teacher B reports a view that C2 should be able to be completed in one visit, as pupils

need all of this information before the circuit construction can commence. She also

reports that she invoked a C2 concurrent visit strategy to enable it.

Teacher B reports that her pupils were very motivated when using the computers, but

that they found it an, "uphill struggle" to complete the other work. However, she also

felt that many of them did not 'explore' enough and took the shortest route to the end.

These two observations bring about an apparent paradox, but one which might be

explained by the access limitation and C2 concurrent visit strategies that she invoked,

both of which might have caused pupils to rush through the courseware.

There were no indications as to whether there was a task match or mismatch as Teacher

A had no established preference and considered that she was too inexperienced to

decide whether using the courseware had affected her pedagogy. There were minor

indications of a frame match, although this should be considered in the light of the

previous sentence. There were some indications of a possible mismatch in teaching

approach. Teacher B's experience had been a linear, process driven project delivery

approach focused on the project folder. She reports that although the courseware could

facilitate a design process, she had some difficulties with getting pupils to record it in

the way that she would have preferred. Again, there may be some concomitance with the access limitation and C2 concurrent visit strategies she invoked. Teacher B also reports feelings of less control over the teaching situation, even though access was strictly managed.

Major Issues

• No experience of this project type

• Indications of a frame match

• Indications of a teaching approach mismatch (Linear process driven - framed task)

• Pupils spending too little time using the computers

• Access limitation strategy invoked

• C2 CV strategy invoked

• Problems getting back

• Less control over learning milieu

• Indications of non-compliance with teacher's practicality ethic

T1 Interview Commentary - Teacher C

Teacher C has a medium level of experience in electronics in the participating group of teachers. She has experience of a type C task although she reports that she did not feel comfortable delivering it. This lack of comfort related mainly to fault-finding ability and, hence, a lack of subject knowledge and expertise. Teacher C also reports that the frame for this previous type C experience was narrower than when using the courseware. However, she is keen to emphasise that using the courseware has improved

her subject knowledge, given her more control over the teaching situation and enabled her to feel comfortable with delivering a type C task with a relatively broad frame. As head of the Learning Resource Centre, Teacher C is something of a champion for educational software and appears to be entirely comfortable with introducing new approaches into her teaching. The factors give indications of a task, frame and teaching approach match.

Teacher C undertook T1 during the Spring Term, whilst Teacher A was completing T2. It was during this period that four computers were moved from the central computing area and into Teacher C's workshop. There are indications in the interview that this took place in the early phases of the trial. This move of resources resulted in Teacher C having four dedicated computers in her more remote workshop and Teacher A having access to the remainder from his workshop in the adjoining computer room. However, it is apparent from the interviews and from the courseware data that some of Teacher B's pupils still used the computers in the central computing area.

Teacher B reports that her pupils were far more motivated to use the computer and complete the electronic circuit than to complete the "folder work". This is in common with Teacher B. She also reports that there was a tendency for her pupils to spend too long on the computers and used phrases like, "spun that out" and "work avoidance" to describe their interactions with the courseware. This is in common with Teacher A.

The interview gives an overall impression of a positive experience and high levels of compliance with S7A and S7B; the highest of the three participating teachers in T1.

Teacher C reports some difficulty with component availability and suggests that the courseware could be modified to narrow the frame to cope with such instances. However, she is clear in her support for choice in enabling the design process in a framed type C task.

In common with both Teachers A and B, Teacher C reports problems with "getting back" after cluster transition has been made. She indicates that new log-ins with high

CV content were encouraged to regain access to material when necessary.

Major Issues

• Experience of this project type

• Indications of a task match

• Indications of a frame match

• Indications of a teaching approach match (LRC Champion)

• Pupils spending too much time using the computers

• Problems getting back

• Indications of compliance with teacher's practicality ethic

T1 Courseware Data

The level of deviant courseware interaction was high (The highest in all schools in all trials). The two main areas for deviance were premature switch-offs, where pupils did not complete a visit and spurious log-ins, where pupils used a made-up name. **The levels of deviant interaction were much higher for Teachers A and C than Teacher B.**
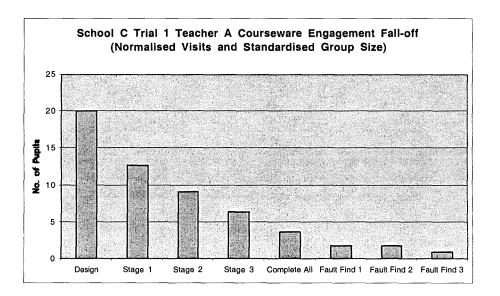
	Total Log-ins	Deviancy rate	Deviancy Level
SCT1 TA C1	0	Corrupt	NA
SCT1 TA C2	4	1.00	0.50
SCT1 TA C3	5	5.00	4.00
SCT1 TA C4	0	Corrupt	NA
SCT1 TA C5	0	Corrupt	NA
SCT1 TA C6	3	2.33	2.33
SCT1 TA C7	8	3.50	1.75
SCT1 TA C8	5	4.00	1.60
			2.04
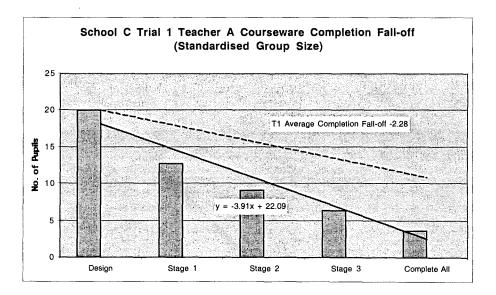
	Total Log-ins	Deviancy rate	Deviancy Level
SCT1 TB C1	9	1.38	1.22
SCT1 TB C2	0	Not Used	NA
SCT1 TB C3	3	1.67	1.67
SCT1 TB C4	0	Corrupt	NA
SCT1 TB C5	0	Corrupt	NA
SCT1 TB C6	8	1.00	0.38
SCT1 TB C7	2	0.00	0.00
SCT1 TB C8	0	Corrupt	NA
			0.82

	Total Log-ins	Deviancy rate	Deviancy Level
SCT1 TC C1	6	1.42	2.83
SCT1 TC C2	0	Not Used	NA
SCT1 TC C3	0	Not Used	NA
SCT1 TC C4	0	Corrupt	NA
SCT1 TC C5	24	1.33	2.67
SCT1 TC C6	26	1.21	1.12
SCT1 TC C7	26	1.65	3.92
SCT1 TC C8	0	Not Used	NA
SCT1 TC C9	0	Not Used	NA
SCT1 TC C10	5	1.50	1.80
			2.47
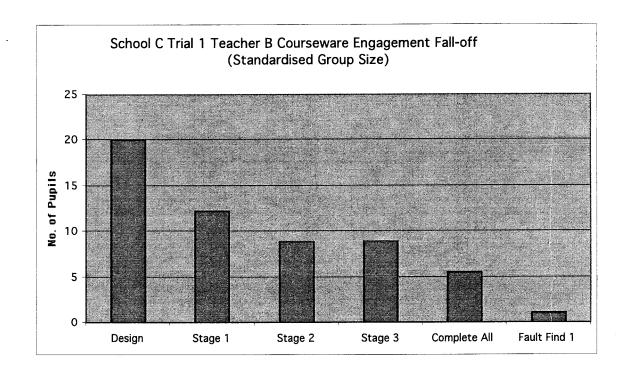
Fig. 118
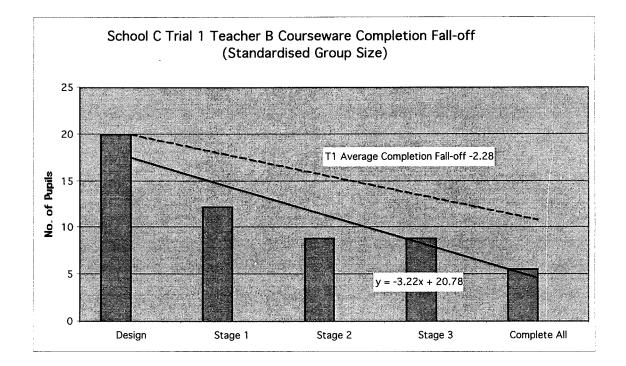
The courseware completion fall-off gradients were all below average (T1 average fall-off gradient -2.28 = 54% completion rate). Teacher A had the steepest courseware completion fall-off gradient (-3.91). His courseware engagement fell-off with a steep curve in the early stages. However, there were some indications of positive fault finding interaction with 2 pupils. Teacher B had the next steepest completion fall-off gradient (-3.22), similar in nature to Teacher A, but with very little fault-finding interaction with the courseware. Teacher C had the shallowest completion fall-of gradient (-2.3) which was close to average. Furthermore, the courseware engagement fall-off showed a much higher level of fault-finding interaction with the courseware.
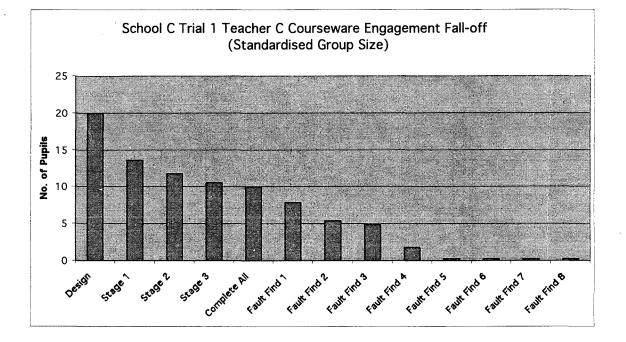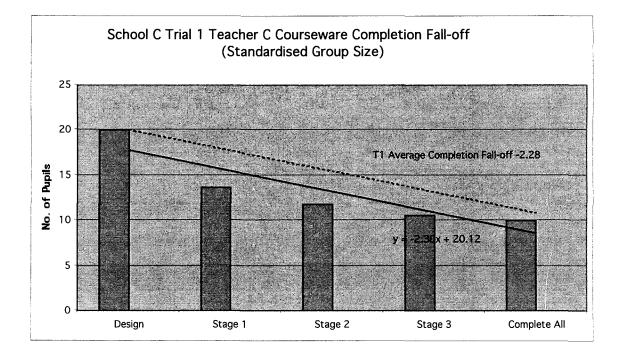
Fig. 119

School C Trial 1 Teacher B Courseware Engagement Fall-off
(Standardised Group Size)

School C Trial 1 Teacher B Courseware Completion Fall-off
(Standardised Group Size)

T1 Average Completion Fall-off -2.28

$y = -3.22x + 20.78$

Fig. 120

School C Trial 1 Teacher C Courseware Engagement Fall-off (Standardised Group Size)

School C Trial 1 Teacher C Courseware Completion Fall-off (Standardised Group Size)

T1 Average Completion Fall-off -2.28

y = -2.3x + 20.12

Fig. 121

The overall visit concurrency profiles show marked differences between Teacher A and Teachers B and C. Teacher A's profile is close to average, particularly with regard to CVs. There is a small shift away from the average, with an increase in SS and a decrease in NS visits. Both Teacher B and Teacher C have large increases in CVs, Teacher B has only CV and SS visits in her group profile indicating that successful courseware completions were all undertaken in a single lesson for each pupil.

Fig. 122
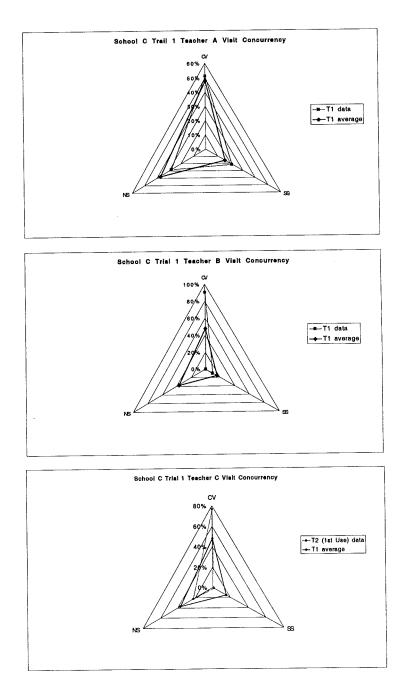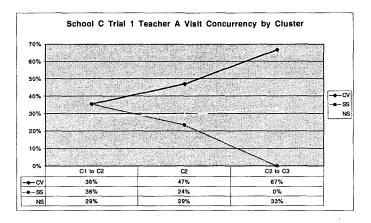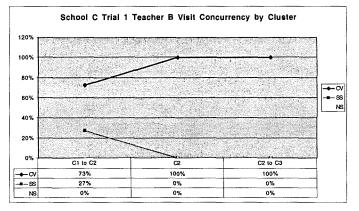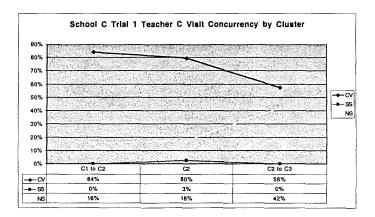
The visit concurrency by cluster showed dominant levels of CVs in all profiles and low levels of congruence with the courseware design intent. The profile for teacher B is particularly startling with 73% CV to 27% SS visits in C1 to C2 and subsequent 100% CVs in all other phases. This is an exceptionally low level of congruence with the courseware design intent. Teacher A's profile is the most congruent with the courseware design intent with regard to NS and SS visits only and shows an improvement as the phases progress. Teacher C's profile shows the greatest trend towards congruence as the phases progress. However, there is still a dominance of CVs in both profiles.

School C Trial 1 Teacher A Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
CV	36%	47%	67%
SS	36%	24%	0%
NS	29%	29%	33%

School C Trial 1 Teacher B Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
CV	73%	100%	100%
SS	27%	0%	0%
NS	0%	0%	0%

School C Trial 1 Teacher C Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
CV	84%	80%	58%
SS	0%	3%	0%
NS	16%	18%	42%

Fig. 123
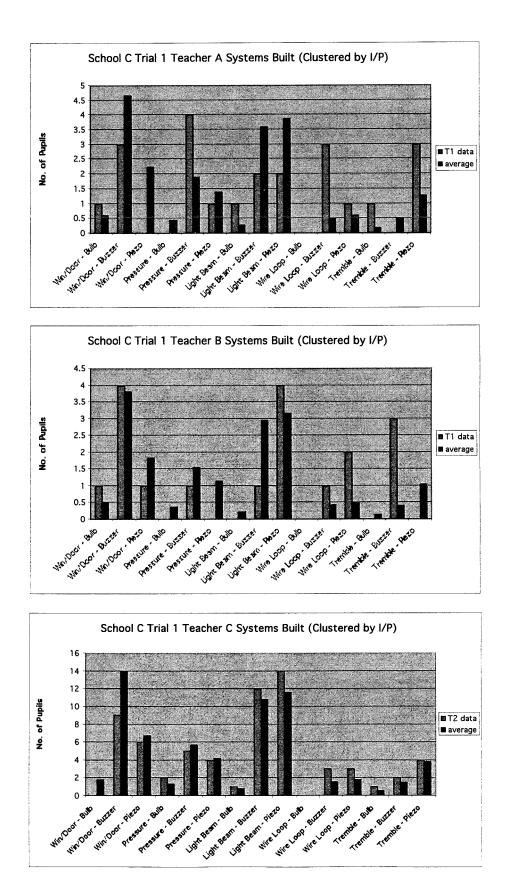
The systems built profiles were close to average for all groups with no significant features in any individual profile.
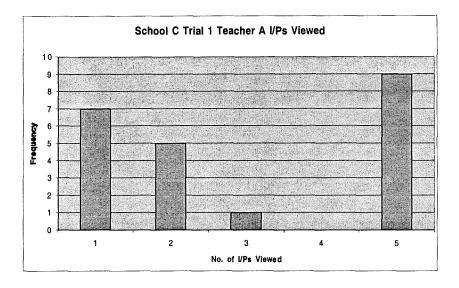
School C Trial 1 Teacher A Systems Built (Clustered by I/P)

School C Trial 1 Teacher B Systems Built (Clustered by I/P)

School C Trial 1 Teacher C Systems Built (Clustered by I/P)

Fig. 124

The systems modification profiles and design visit profiles indicate low levels of heuristic interaction with the courseware. In group A one pupil changed their input from a wire loop to a tremble switch after the first visit indicating a possible improvement to system performance in the application context. One more pupil radically changed their complete system on their 3rd visit. There were no more subsequent visits suggesting that this change may have been arbitrary. **In group B there were no changes made at all.** In group C Four pupils made changes all of which appeared to improve the system performance with respect to an intended application context.
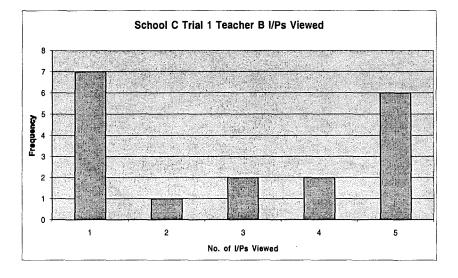
SCT1	Change Possibility	System Changes	
Teacher A	61	2	3%
Teacher B	27	0	0%
Teacher C	119	6	5%
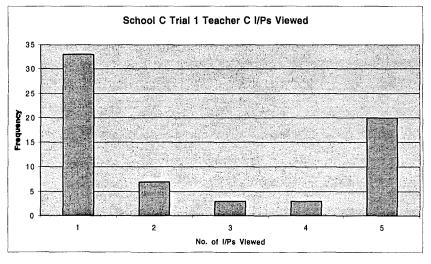
Fig. 125

The design visit profiles show a low level of compatibility with heuristic approaches to the use of C1, all profile curves being the inverse of a compatible distribution.

Fig. 126

Fig. 127
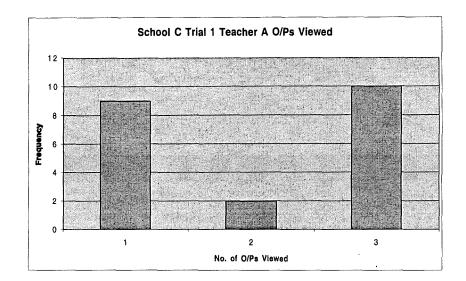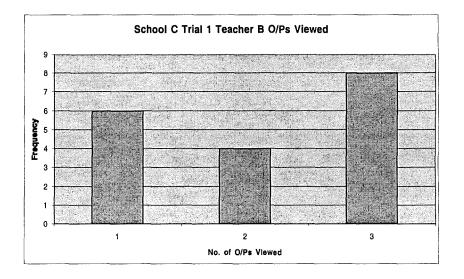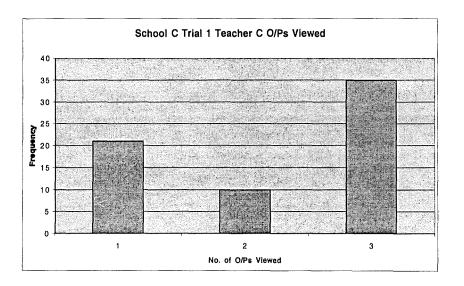
Because of the complexity of these learning milieux with regard to the number of computers available, and the high levels of deviant courseware interaction, no attempt has been made to analyse performance by log-in order.

T1 Courseware Data Commentary

The most significant feature of this learning milieu is its complexity, brought about by the number of computers that have been used to support the courseware. A natural assumption might be that an increase in resource of this kind would positively affect a range of profiles in the courseware data sets. However, this appears not to have been the case. In many areas the performance was worse than average .

In the case of deviant courseware interaction there was a very significant rise in both incidence and severity. After the courseware data was collected there were a number of examples that had become completely corrupted. The most common incidence of deviant interaction were for premature switch-offs, where pupils switch-off or reboot the computer before a visit is complete, followed by spurious log-ins where pupils use a made up name. On viewing the user models, and particularly those of the worst cases, it appears that many of these premature switch-offs were during orientation activities. If the answers to the question could not be found then some pupils repeatedly rebooted the computer in an attempt to bypass the orientation activity. There were instances of some pupils making repeated log-ins to other computers, reaching the same stage and then repeating this deviant behaviour. In more than one case pupils repeated this behaviour on several computers and in some instances caused complete corruption of the courseware. This behaviour gives the impression that there is a cultural element to this learning milieu when children are using computers. If they encounter difficulty then the reaction is not to enquire, but to reboot. It is also evident that levels of courseware use supervision are likely to have been lower than in other learning milieu. This may simply be as a result of the physical geography or the high number of computers available.

They may also be some correlation with this feature of rebooting to avoid an orientation activity and a high incidence of CV's, where pupils have not undertaken any practical activity between visits and have been allowed or encouraged to adopt a CV strategy in a learning milieu with no computer access problems. From the profiles shown it is evident that Teacher B has achieved far lower levels of deviant courseware interaction than Teachers A or C, even though the 0.82 coefficient is still higher than any other trail in any other school. The only evident feature that may explain this difference is the access limitation strategy that she invoked in order to feel comfortable and to remain in 'control'. Hence, in this learning milieu, higher levels of courseware supervision have lead to lower levels of deviant courseware interaction.

It might be expected that increasing the availability of computer-time for pupils would benefit the courseware completion profiles. However, all of the courseware completion fall-off gradients were steeper than average. The profiles for Teacher C were significantly more congruent with the courseware design intent than those for Teachers A and B. The courseware completion fall-off gradient for Teacher C was a little below average (-2.3), and those for Teachers A and B were well below average (-3.91 and -3.22 respectively). In the courseware engagement fall-off profiles further differences emerge in the use of the courseware. The profile for Teacher B is the least congruent with the courseware design intent. Only one of her pupils used the courseware for fault finding, and this pupil only made one visit. This profile may be a result of the access limitation and C2-CV strategies that she invoked to 'manage' the courseware use. The profile for Teacher A is similar to that for teacher B. It shows a slightly higher use of the courseware for fault finding, but has a steeper fall-off gradient to the point of courseware completion. From the reflective accounts of both of these teachers there are indications of a teaching approach mismatch. The more experienced Teacher A feels most comfortable with a teaching approach that divides theory and practice (resource/ capability). He feels that pupils should be 'primed up' before undertaking a design and make assignment. He feels that this has been lost and that pupils now bring their own agendas to the lessons. The inexperienced Teacher B places significant emphasis on a

folder centred 'design process'. Her descriptions of this process give the impression of a linear activity and one that she uses to record and control the activities of her groups. She feels that this aspect of her teaching approach has been diminished by using the courseware and that access has to be limited if she is to maintain control. These mismatches in teaching approach are not evident in the reflective account of the partially experienced Teacher C. Her secondary role in the Learning Resources Centre mark her out as a 'champion' for resource based learning approaches. She reports that the courseware is very supportive and has helped her to overcome her deficits in subject knowledge and to learn new techniques form the experience. These features indicate some concomitance with teaching approach match and courseware completion and that this concomitance is not affected by the level of 'management' of courseware use.

The overall visit concurrency profiles show marked differences between Teacher A and Teacher's B and C. The profile for Teacher A is close to average, which would indicate that access to the courseware has not been limited by him. The visit concurrency by cluster for Teacher A shows a decreasing level of congruence with the courseware design intent as the project progresses. Hence, in the initial project phases there are indications that Teacher A has managed the use of the courseware in a manner that is congruent with the courseware design intent (pupils undertaking activities between visits), and this management has diminished as the project progressed. Making the printed circuit board at the end of C1 is something of a 'way-point' in the project. The control of activities leading up to the realisation of this component are necessarily teacher controlled because access to the required resources and expertise by the pupil must be through the teacher rather than the computer. The control of activities after this point can be subject to a number of factors, but are biased towards the pupil, particularly in this learning milieu where there are a large number of computers supporting the courseware and they are remotely situated. The visit concurrency profiles for Teacher B are congruent with the access limitation and C2-CV strategies that she invoked. All successful courseware completions have been undertaken in a single lesson; an approach that has no congruence with the courseware design intent. The dominant

levels of CVs, particularly in C1, in the visit concurrency profiles for Teacher C are not congruent with the indicated task, frame and teaching approach match. There is a slight trend towards congruence as the project progresses, but there is still an overall dominance of CVs in all phases. This paradox might be explained by her explanation of how she overcame the problems she encountered with pupils "getting back' after cluster transition. Rather than sharing the work of another pupil or supplying the information herself she encouraged pupils to log-in again, on a new machine, and to 'blitz through' the courseware to get at the information that they had 'missed'. The effects of this strategy on the visit concurrency profiles are supported by the levels of deviant interaction evident for Teacher C. They were the highest in the trial even though she had 'decanted' four computers into her own workshop effectively limiting computer time and increasing her opportunity to supervise courseware interaction at a micro level.

The systems built profiles were close to average for all groups, which indicates that although there were a variety of courseware management strategies operating across the groups, and differing levels of compatibility with teaching approaches, there was little teacher intervention in courseware interaction. The pupils were allowed to work on whatever system they wanted to. This would support the indications of both a task and frame match.

The systems modification profiles and design visit profiles again showed very low levels of heuristic interaction with the courseware. However, it is significant that the profiles for Teacher B are the least congruent with no system changes at all (0%). For Teacher B there is a slight rise (3%) and for Teacher C a further rise (5%). Teacher B's courseware management strategies and her pupils completion of the courseware in a single lesson may well explain the 0% outcome. The significant difference between Teachers A and C is the teaching approach match/mismatch. It may be that the match in teaching approach for Teacher C has stimulated the slightly higher levels of heuristic interaction with the courseware than for Teacher B.

T1 Significant Features

1. Many computers

2. High levels of deviant courseware interaction (A, B, C)

3. Significantly lower levels of deviant interaction (B)

4. Task match (A & C)

5. No task type experience (B)

6. Frame match (A, B & C)

7. Teaching approach mismatch (A & B)

8. Teaching approach match (C)

9. Pupils spending too long (A, C)

10. Pupils rushing through (B)

11. Access limitation strategies (B)

12. C2-CV strategies (B)

13. No courseware management strategies (A & C)

14. Some computers moved into workshop (C)

15. Less control over learning milieu (B)

16. More control over learning milieu (C)

17. Highest levels of courseware completion (C)

18. Medium levels of completion (B)

19. Lowest levels of courseware completion (A)

20, Problems 'getting back' (A, B & C)

21. Indications of compliance with teacher's 'practicality ethic' (A & C)

22. Indications of non-compliance with teacher's 'practicality ethic' (B)

T1 Concomitant Features

Teacher A

Fig. 128

Teacher B

Fig. 129

Teacher C

Fig. 130

Trial 2
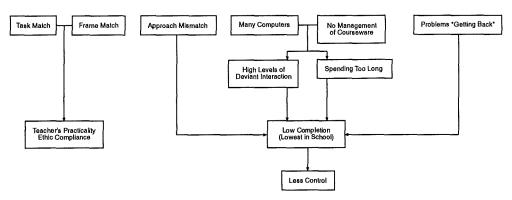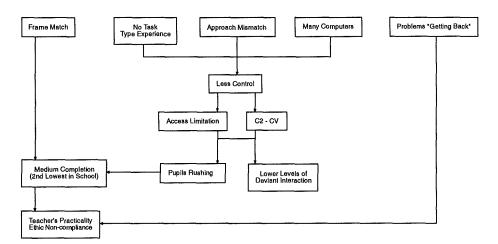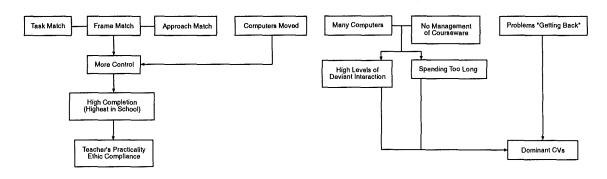
Trial 2 took place throughout the Spring term with Teacher A taking two groups. The only significant difference in arrangements between T1 and T2 was the number of computers available. Four computers had been moved into the more remote workshop for use by Teacher B who was undertaking T1 at the same time. This left Teacher A with the courseware installed on 6 computers in the computer area adjacent to his workshop. Again no problems were reported during this trial phase. However, in common with T1, when the courseware was collected one version had become completely corrupted.

In line with the methodology model developed for this current research Teacher A was interviewed after T2 was completed using the adopters' interview schedule. The complete interview text is available in appendix 3.3.

T2 Interview Commentary - Teacher A

From the T2 interview there are indications that Teacher A has modified his teaching approach in light of his T1 experiences. He recognises the ability of the courseware to support a type C task with high levels of pupil procedural autonomy. He reports that the courseware has enabled him to pass control of the project over to his pupils to a greater extent than in any other area of his experience. His previous teaching approaches have been focused on maintaining control in a challenging school by keeping a, "strict reign on proceedings". There are indications that he is re-evaluating this approach in the light of his T1 and T2 experiences.

Teacher A agrees, "philosophically" with procedural autonomy as an indicator of capability, but still has reservations about whether similar levels of autonomous action can be offered to all of his pupils. His view is that differentiation must be applied by limiting the brief frame for less 'able' pupils; as far as a single choice for his least able.

These reservations may have some concomitance with his preferred teaching approach highlighted in T1 (resource/capability), and his observations that some pupils, "gloss over" the courseware contents. These reservations indicate some tension between the courseware design intent, with regard to pupil procedural autonomy, and Teacher A's feelings of control over his learning milieu. He again reports how a, "virtual laboratory" approach would not get a, "result" in his learning milieu, so he is supportive of the guided discovery mechanism offered by the courseware, but he would perhaps wish to limit levels of procedural autonomy to a further extent.

In contrast to these feelings, Teacher A is an advocate for the use of IT based learning resources in the department and demonstrates an understanding of the courseware design intent by offering plausible suggestions as to how this courseware development paradigm could be deployed in other areas. In T2 Teacher A still had access to 6 computers located in the adjacent computer area. These factors indicate that a task and frame match are still evident and that there is a move towards a match in teaching approach. However, a feature of this learning milieu causes Teacher A to have reservations about how 'in control' he is of the learning milieu when compared to his previous experience. It may be that the most significant feature of this trial, the number of computers available, coupled with their location, contribute to these feelings of insufficient control when a task, frame and teaching approach match are achieved. Teacher C reported greater levels of control in T1 and there were indications of this component match, albeit with a stronger match in teaching approach. The significant difference between the two learning milieux was the situation of the computers used to support the courseware. In the case of Teacher C they were in the workshop and with Teacher A they were in an adjoining room. The physical geography will have an effect on the ability of the teacher to supervise the use of the courseware on macro and micro levels and, when the computer numbers are relatively high, this would indicate that the ease of supervision has some concomitance with the teachers' feeling of control over the learning milieu.

In common with T1, Teacher A reports problems with 'getting back' after cluster transition. He does not cite this as a major problem, but reports that pupils, " have to go right back to the beginning again to go through". This strategy would contribute to the levels of indicated deviant interaction as it is only possible by logging in to an alternative machine or using a different log-in name; a situation that is made more possible as the computer numbers available rises.

Major Issues

• Indications of a task match

• Indications of a frame match

• Indications of a move towards a teaching approach match

• Improving levels of control

• Problems getting back

• Indications of compliance with teacher's practicality ethic

T2 Courseware Data

The level of deviant courseware interaction fell significantly (T1 2.04 - T2 1.33).
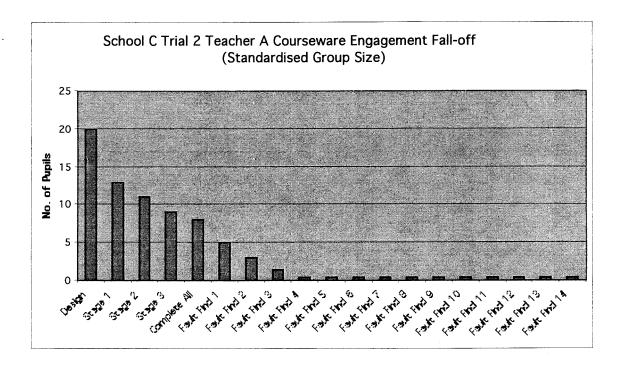
The level of deviant interaction was still higher than in any other school and higher than

for Teacher B in T1.
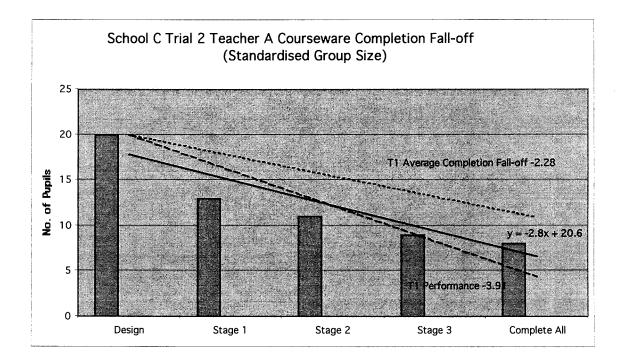
	Total Log-ins	Deviancy rate	Deviancy Level
SCT2 TA C1	13	1.11	0.77
SCT2 TA C2	6	2.00	1.33
SCT2 TA C3	15	1.38	1.47
SCT2 TA C4	4	1.00	0.25
SCT2 TA C5	5	1.00	0.60
SCT2 TA C6	0	Not Used	NA
SCT2 TA C7	5	1.00	3.20
SCT2 TA C8	0	Corrupt	NA
SCT2 TA C9	0	Not Used	NA
SCT2 TA C10	9	1.25	1.67
			1.33

Fig. 131
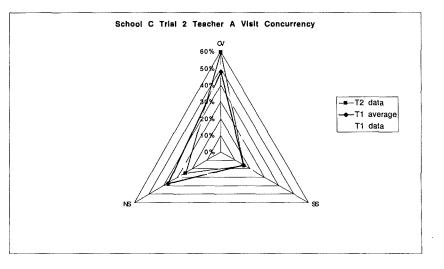
There was a significant improvement courseware completion fall-off gradient. The

gradient was close to average indicating a higher level of courseware completion. The

fall-off curve was more linear indicating much less courseware drop-out after

completion of C1. The curve also indicates improved levels of fault finding interaction

with the courseware. However, in this area one pupil exhibits very untypical behaviour

in that they have made fourteen visits to the fault-finding section of the courseware.

This may indicate a lack of understanding of the fault finding guidance, an inability of

the fault-finding guidance to rectify the fault (this is the only instance of such

interaction) or a pupil playing with the courseware to avoid further work. The user

model for this pupil indicates the latter of these three options as the visits are

scatological - sometimes viewing every screen available, sometimes doing nothing but

logging in then out again and with the major fault symptoms changing regularly.

School C Trial 2 Teacher A Courseware Engagement Fall-off
(Standardised Group Size)

School C Trial 2 Teacher A Courseware Completion Fall-off
(Standardised Group Size)

T1 Average Completion Fall-off -2.28

y = -2.8x + 20.6

T1 Performance -3.9

Fig. 132
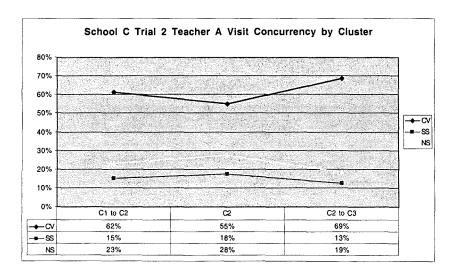
The visit concurrency profiles show a movement towards the average. This is

achieved via a fall in CVs with an associated rise in NS and SS visits. This move

represents a shift towards greater congruence with the courseware design intent.

However, the visit concurrency by cluster still shows and overall dominance of CVs

ranging from 55% to 69%. This represents a low level of congruence with the

courseware design intent. The rising trend of the CV component of the profile observed

in T1 has flattened out. This would indicate slightly greater congruence with the

courseware design intent in the later phases of the project in T2 but a fall in congruence

during C1.

Fig. 133

	C1 to C2	C2	C2 to C3
CV	62%	55%	69%
SS	15%	18%	13%
NS	23%	28%	19%

Fig. 134

The systems built profile is again close to average with no significant features.
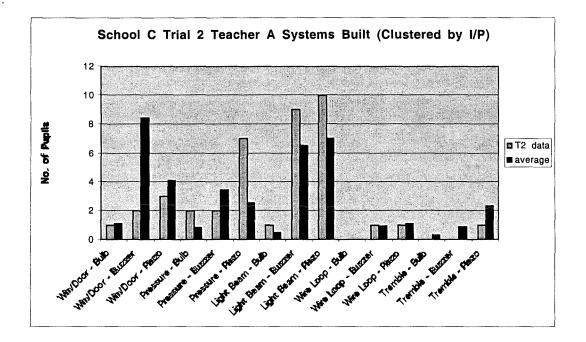
Fig. 135
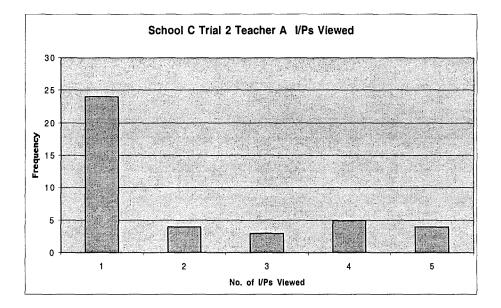
The systems modification and design visit profiles indicate low levels of heuristic interaction with the courseware. During T2 there were no modifications made to systems at all in either of the groups being taught by Teacher A.

Change Possibility	System Changes
66	0
	0%
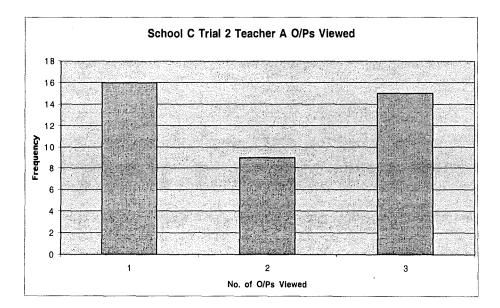
Fig. 136

The design visit profiles show a low level of compatibility with heuristic approaches to the use of C1, all the profile curves being the inverse of a compatible distribution. However, there is a noticeable flattening out of the 'U' curve for I/Ps viewed in its upper reaches.

Fig. 137

Fig. 138

T2 Courseware Data Commentary

The courseware data indicate a change in performance across a range of aspects in T2. These improvements were focused on three major areas: a fall in deviant interactions; a shallower completion fall-off gradient; a small move towards the average in the overall visit concurrency profile. The most significant differences between T1 and T2 being a change in the computer numbers available and an indicated move towards a match in teaching approach. Evidently there is some concomitance between these three improved performance indicators and these two significant differences between the two trials. A reduction in available computers and, by the complete relocation of the other teachers groups, the number of pupils requiring access to them, increases the opportunities to easily supervise the courseware use. A move towards a teaching approach match, stimulating better use of the courseware and incentives to encourage completion by the pupils. However, even though there are improvements in both the deviant interactions and visit concurrency profiles there is still a low level of congruence with the courseware design intent. The levels of deviant interaction are the third highest for any school in any trial and higher than any trial in both schools A and B. The visit concurrency profiles have an unacceptable dominance of CVs, both overall and by cluster. The concomitance between the reduction in computer numbers and the improvement in deviance levels and CV levels between T1 and T2 is further supported by the levels of these two indicators. When they are compared to other trial schools where far fewer computers were available to support the courseware the levels of deviant interaction were much lower in all cases and the CV profiles were much improved when there was a similar task and frame match. Moreover, the encouragement to pursue a fresh log-in if problems of 'getting back' are encountered would also increase the CV component of the visit concurrency profiles when there are sufficient computer numbers to enable this strategy to be implemented.

The courseware data also show some minor indications that interactions with the courseware have been managed during T2. There are no specific references to this in the

interview as there were for Teacher B in T1. However, the systems modification and
design visit profiles are atypical of the school and other trial schools in both T1 and T2.
The systems modification profile shows no system changes at all for any pupil in both
of the groups that were taught by Teacher A during T2. Although the instances of system
changes was low for all schools in all trials, there was only one other instance of a 0%
change taking place. This was for Teacher B in this same school, where management of
the courseware interactions was made explicit in the interview transcript and supported
by differences in courseware data across the three participating teachers. The most
significant element of this interaction management was a fall in deviant courseware
interactions. The design visit profile for inputs viewed is again atypical for all schools
and all trials. There is a predominance of pupils viewing one input option and a flat
response of a few (<5) pupils viewing 2, 3, 4 or 5 options. There is no rise in the
numbers of pupils viewing 4 or 5 options to form the 'U' curve that is typical across all
schools in all trials. These factors would suggest that pupils had already made decisions
about what their system was before they began interacting with the courseware. A
different management strategy from Teacher B in T1, but management of courseware
interactions nonetheless as pupils approach it with no design or problem solving agenda,
but simply use it to assemble the information necessary for them to build their circuit.
This would suggest that Teacher A had changed his teaching approach from T1, but had
probably moved away from a teaching approach match rather than towards it. He had
used the experience of T1, particularly the knowledge gained concerning what the
courseware will enable the pupils to achieve, to enable him to follow his preferred
teaching approach, i.e. by "priming them up" with knowledge before letting them loose
on the computers. Such a change would give Teacher A enhanced feelings of control
over the learning milieu where there are large computer numbers and he only feels in
control when they are driving the project agenda.

T2 Significant Features

1. Many computers

2. Less computers than T1

3. High levels of deviant courseware interaction

4. Some improvement in deviance levels

5. Task match

6. Frame match

7. Teaching approach mismatch

8. Management of courseware interaction

9. No problem solving or design agenda

10. Zero heuristic interaction

11. Improved feelings of control

12. Improved courseware completion

13. Problems 'getting back'

14. Predominant CVs

15. Indications of compliance with teacher's practicality ethic.

T2 Concomitant Features

Teacher A
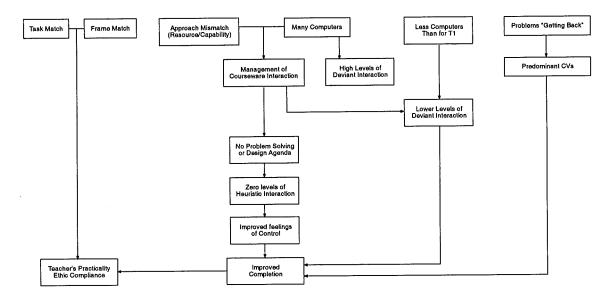
Fig. 139

The Development of Intelligent Hypermedia Courseware, for Design and Technology in the English National Curriculum at Key Stage 3, by the Sequential Combination of Cognition Clusters, Supported by System Intelligence, Derived from a Dynamic User Model

A thesis submitted to Middlesex University in partial fulfilment of the requirements for

the degree of Doctor of Philosophy

Andrew Bardill

School of Lifelong Learning and Education

Middlesex University

February 2003

Chapter 5 - Recurring Concomitants and Critical Processes

The design of the courseware development paradigm resulting from this current

research project, and the subsequent form and content of the courseware instantiation

used for the trials, was guided by three principal design criteria: the situation that the

courseware would be used in; the task that it would be designed to support; and the

pedagogy that it would reflect and support. It is, therefore, useful to return to these

guiding design criteria to describe what the recurring concomitants in the trials were and

what critical processes emerge from them. In common with the design process there are

elements of interrelationship between the three guiding criteria and these are most

evident with the task and pedagogy considerations. During the design process these two

criteria were more separate as the task criteria were more concerned with describing a

taxonomy of task types (A,B,C) and the pedagogy criteria focused on the structure of

the hypermedia and users' interactions with it. However, when the courseware is

deployed in the learning milieux these two criteria become merged as the task type is an

integral, and leading pedagogical element of the learning milieux.

Situation Features

The two principal recurring features relating to situation to emerge from the trials are

the number of computers available to support the courseware and the physical

environment in which the trials took place.

There is no evident link between the number of computers available to support the

courseware and the levels of courseware completion. A higher number of computers

makes a greater amount of computer time available to each pupil, but did not lead to

greater levels of courseware completion. The highest levels of courseware completion

were in School B which had a single computer of the lowest specification and the

slowest printer for any trial. In this school Teacher A managed to achieve 100%

courseware completion during T2. The levels of courseware completion in School B

were the highest for any school and any trial. The next highest levels of completion

were in School C where there were up to ten computers of a high specification and a

networked laser printer. However, this level of facility did not universally affect the

completion rates in this school. In fact the lowest rates of completion occurred when all

computers were used and the highest when a small number of computers were moved to

an individual workshop. This begins to suggest an inversely proportional relationship

between computer numbers and courseware completion. However, the results from

School A negate this neat relationship. The courseware was supported by two computers

in School A which were situated in the workshop. However, the courseware completion

rates were the lowest for any trial in any school. It is evident that there are other

processes at work which affect courseware completion rates and they do not relate to the

number of computers that are available to support the courseware. There were, however,

indications that a 'saturation point' can be reached when computer numbers are reduced

to the minimum. This occurred in School B during T1 at approximately 16 to 18 pupils.

During the trial there was a direct relationship between pupil numbers and courseware

completion fall-off gradients; more pupils gave steeper gradients and the last few pupils

to log-in to C1 were least likely to complete the courseware after this saturation point

had been exceeded . This saturation point did not occur in T2 in School B even though

the groups were of similar size. In T2 the completion rates were again subject to other

processes that do not relate to computer numbers. Even in situations where computer

numbers and performance have been pared back to the absolute minimum, it is still

possible to support the courseware if other factors are favourable.

Neither did courseware completion have any relationship to general ability of the

participating pupils. In School A the general ability level is demonstrably higher than in

both Schools B and C yet the courseware completion in T1 was only slightly below

average and in T2 was the worst in any school in any trial. Again other processes must be operating to affect courseware completion levels.

There is an evident link between the physical environment and the level of deviant courseware interaction. This is not a clean and easy link to define as other factors from the task/pedagogy considerations can also operate, but as teachers lose the ability to supervise the use of the courseware on both macro and micro levels, brought about by factors to do with the physical environment, then the level of deviant interaction increases. The physical environment factors relate to both computer numbers and their separateness from the working environment; larger numbers of computers and/or a greater separateness from the central working environment leads to a situation that is more difficult to supervise and subsequently increased levels of deviant interaction with the courseware occur. Again this level of deviance does not have a relationship to the general ability of the participating pupils. The levels of deviant interaction were lowest in School A which might suggest a link. However, the levels of deviant interaction were radically different in Schools B and C, which have very similar general ability levels in their pupils but very different physical environments.

To understand the nature of this deviant interaction, rather than simply poring over the figures provided by the courseware data, it is useful to classify the deviance in broad descriptive categories thus: 'poggling', subversion and redemption. 'Poggling' and subversion are the deviant activities that relate to the physical environment and, hence, the ability of the teacher to supervise the courseware use. Redemption is different in nature, does not relate so closely to the teacher's ability to supervise the use of the courseware and points towards a potential need for development in subsequent iterations of the courseware.

Poggling is where pupils are seemingly on task, but are making no forward progress. In this current research project poggling is essentially work avoidance, where pupils prefer to be entertained by the computer rather than to engage with the project. Poggling is typified by user models that are exceptionally long or where the same pupil logs in to a

number of computers using their correct or similar names. The most common instances of poggling are in milieux where there is no pressure on computer time and/or the computers are distantly situated from the central working environment, so the poggling is less easy to spot.

Subversion is typified by two main activities. The first is where pupils switch-off the computer prematurely in an attempt to get past an element of the courseware that is troublesome. In some instances this can escalate into 'reboot fever' where pupils repeat this behaviour on a number of computers and in some particularly severe instances have rendered the courseware inoperable. The most common instances of 'reboot fever' were in School C where the pupils are most familiar with using computers, there were the largest number of them and they were distantly situated from the workshop. However, 'reboot fever' was the most rampant when CVs were highest also. When pupils did not complete any practical activity between courseware visits the orientation exercises became difficult and a few pupils went to considerable lengths in attempting to avoid them. The second form of subversion is where pupils log in to the computer using a made-up name. From the user models collected it was evident that these names were informed by particular affiliations that pupils had with fashion, pop groups, football teams etc. whereas others were obscene in nature. In all cases these spurious log-ins were short and rarely progressed past the first visit. There are evidently overlaps between this second form of subversion and poggling.

Redemption is typified by extra log-ins to recover data from the courseware that has been missed and is associated with the recurring feature of problems 'getting back'. This problem is concerned with accessing earlier cognition clusters after a transition has been made. It is possible to access C1 from C2 in order that decisions made about system blocks can be modified. Hence, this transition is not a component of the perceived problem. Furthermore this backward link was rarely followed as is shown in the exceptionally low figures for system modification in all trials in all schools. C2 is the cluster where information is obtained about the three system blocks: input; process;

output. It is possible to revisit any of these stages whilst in the cluster and to make modifications by revisiting C1. During the instantiation phase of the courseware the decision was taken to make an automatic transition from C2 to C3 after the three stages had been visited at least once, and, thereafter another automatic transition after C3 has been completed. It is these automatic transitions that have caused some problems with 'getting back' when pupils have not printed essential information. The reasons for the selection of automatic transitions was to minimise potential poggling in situations where computer time would be limited and to maximise forward progress on the task. However, as the trials have shown, poggling is least evident in situations where computer time is limited and, hence, this component of the courseware development paradigm should be reappraised. The difference between a poggler's and a redeemer's extra log-ins are evident in the user models. A poggler will either aimlessly browse through the courseware, or loop continuously around the more entertaining areas, whereas a redeemer will purposefully navigate to the information that they have missed. However different the activities are, both are wasteful of time and represent deviant interactions. Again redemption was most prevalent in situations where computer time was most plentiful. Two reasons may explain this: one being that the availability of plentiful resources enabled teachers to recommend it as a strategy; the other being that loose supervision of courseware use, in situations where the physical environment make tight supervision difficult, leads to information being skipped through and a greater necessity for redemption activities to take place . The need for redemption to take place at all and the recurrence of the reported problem of 'getting back' highlights a need for further work on these courseware control features in subsequent iterations.

A subset of redeemers emerged when the courseware data from School C was analysed. This subset of users have been termed as the 'solitary-disadvantaged' as they appear to have difficulty working with courseware of this type when supervision levels have been depressed as a result of the situation based factors. They are not evident in Schools A or B, but seem to have emerged in School C where the physical environment has enabled them to become noticeable. The solitary-disadvantaged are typified by pupils who are

trying to engage with the courseware but have some evident difficulties. They sometimes have difficulties spelling their names the same way repeatedly and use two or three similar spellings. The log-on algorithm used for the courseware will instantiate a new user model with each new spelling, and invoke unexpected responses from the courseware with subsequent different usages. These pupils also seem to forget which computer they have been using between visits. Again this will cause new user models to be instantiated when first visiting a new computer and old and out of sequence usermodels to be invoked when changing computers. This second problem would be removed for these pupils if the user model data was networked; a level of functionality that was not achievable in this first prototype. However, it is evident that members of this group need some supervision when using the courseware, whether this is provided by a teacher or a peer, and this level of supervision is more difficult to provide in situations where there are a large number of computers and they are distantly situated from the working environment. A particularly severe example of this group appeared in School C. This pupil had managed to log in to all ten computers and had used a number of different arrangements of their first and second name, which had two different spellings. The usermodels indicate attempts to complete similar alarm systems. This would constitute 'world-class' poggling and would be difficult to describe as entertaining to the pupil.

The critical process that emerges from this link between levels of deviant courseware interaction and the physical environment can be expressed in terms of the two constituent components of the environmental factors (computer numbers and their positioning) and the three classes of deviant interaction (poggling, subversion and redemption).

In terms of computer numbers, there will be an increase in poggling as computer time becomes more plentiful. There were no instances of poggling in Schools A and B and plenty of instances in School C. As computer time becomes more plentiful there will also be an increase in redemption. There were no instances in School A, minor instances

in School B with Teacher B and plentiful instances in School C. As computer time becomes more plentiful redemption becomes a viable strategy for pupils who have missed, or not printed, essential information. With an increase in redemption there will also be an increase in the subset of the solitary-disadvantaged. As computer time becomes more plentiful, less questions are raised about who is using which computer, and for what purpose, and supervisory efforts are more thinly spread.

In terms of the situation of the computers, there will be an increase in subversion as the computers become more distantly situated from the central working environment. Repeated rebooting and logging-in using an obscene or spurious names are far less likely under close supervision. There were no instances of subversion in School A where two computers were used in the workshop, some instances in School B where one computer was used in a separate room and plentiful instances in School C where there were many computers in a separate area. The situation of the computers does not appear to affect the level of redemption as the viability of this strategy relates to the availability of computer time. However, the situation of the computers is the second component of a 'double-whammy' for the solitary-disadvantaged who have difficulty making any substantive forward progress without close supervision.

Critical Process 1 - Physical Environment and Deviant Courseware Interaction

a) Computer Numbers

Poggling, Redemption &
The Solitary-disadvantaged

Computer Numbers   INCREASE

b) Computer Situation

Subversion &
The Solitary-disadvantaged

Computer Position   More Distant
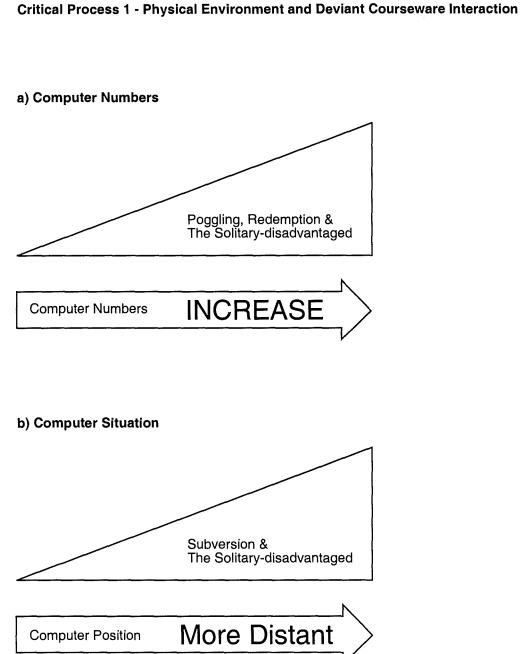
Fig. 51

There are indications of a link between computer numbers and teacher management of pupils' courseware interactions. The nature of this management changes with respect to computer numbers and task/pedagogy factors, but is essentially focused on completion when computer time is limited and control when computer time is plentiful. In School B, where there was only one computer, there were indications that Teacher A had

invoked a cluster 2 concurrent visit strategy (C2-CV) in T1 whilst maintaining high

levels of congruence with the courseware design intent in other clusters. This evident

strategy was further amplified in his data for T2 and had filtered across to Teacher B in

T2. This C2-CV strategy was a significant factor in the exceptionally high levels of

courseware completion achieved in this learning milieu. However, it must also be noted

that these high levels of completion were also achieved in a milieu where the task/

pedagogy factors were also favourable. This C2-CV strategy is contrary to the

courseware design intent, but in light of the performance of the courseware in School B

it highlights a potential need for further development of the cluster structure in

subsequent iterations of the courseware.

In School C, where computer time was plentiful, there were two different management

strategies invoked by teachers in situations where the task/pedagogy factors were

largely favourable. Although different in nature both of these strategies were contrary to

the courseware design intent and both related to control of the learning milieu. In T1

Teacher B invoked an access limitation strategy whereby only 3 or 4 pupils at a time

were allowed to use the courseware and build the electronic circuit. Teacher B also

indicated that she had invoked a C2-CV strategy. This may well have been the case, but

the data show that virtually all visits to the courseware by her pupils were completed in

a single lesson, which effectively mask it. However, it is interesting to note that the

same stimulus for courseware modification occurred in two very different learning

milieu. The closer supervision afforded by this access limitation strategy resulted in the

lowest figure for deviant interaction in this school in any trial, but had no significant

impact on courseware completion, which remained as the second worst for any trial in

this school. The only other significant outcome from this strategy, apart from lower

levels of deviant interaction, were enhanced feelings of control for Teacher B in a

situation where there were indications of a teaching approach mismatch. In T1 Teacher

A reported some loss of control over the learning milieu and an improvement in control

in T2. From the courseware data (number of options viewed, number of system

changes) there are indications that Teacher A had reverted to his preferred teaching
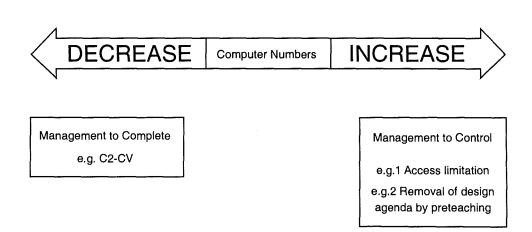
approach (resource/capability) in T2. His pupils had made their decisions before they accessed the courseware and, hence, had no design agenda when using it. This strategy resulted in no heuristic interaction with the courseware, but improved levels of courseware completion. Again this management strategy relates to control of the learning milieu in a situation where there are indications of a teaching approach mismatch and computer time is plentiful.

No teacher invoked management strategies were evident in either trial in School A. However, this was in a situation where the task/pedagogy factors were not favourable and there was diminishing motivation for the courseware to succeed as the trials progressed.

The critical process that emerges from this link between computer numbers and teacher invoked management strategies can be expressed in terms of the computer numbers available and the related themes of completion and control, but is negated by a task mismatch.

Critical Process 2 - Computer Numbers and Teacher Invoked Management Strategies

Task Mismatch Negates the Process

DECREASE | Computer Numbers | INCREASE

Management to Complete

e.g. C2-CV

Management to Control

e.g.1 Access limitation

e.g.2 Removal of design agenda by preteaching

Fig. 52

Task/Pedagogy Features

The three principal recurring features relating to Task/Pedagogy to emerge from the trials are whether the courseware provides a task type match, a frame breadth match and a teaching approach match. The match of task, frame and approach are dependent on the preferences, practices and philosophies of the participating teachers as they were not stipulated as a condition of participation in the trials. These three features appear to have a multidimensional effect, but are the most significant indicators of courseware performance, compliance with teacher practicality ethics' and subsequent acceptance and adoption by the teacher. There is also evidently a hierarchical relationship between these three features - where task is most significant and approach is least significant.

The task type match refers to the taxonomy of task types described in chapter 2. The courseware is designed to support a type C task and was used by the majority of participating teachers to do so. However, there were strong indications that this was not the case in School A. Teacher A's practice at this level had previously been concerned with type A tasks (make this circuit) and the departmental delivery model for KS3 was structured around a 'skills-round' of sequential focused practical tasks in different material areas. Teacher A also had personal reservations about how the levels of pupil procedural autonomy required for a type C task might be achieved with 'teenagers'. From the indications provided by the courseware data, particularly the systems built profile, it became evident that the courseware had not been used to support a type C task. Nor had it been used for a type A task. The systems built profile was narrow, but not unitary. After further analysis it became apparent that a kind of sub-type B task had been undertaken by the pupils (make a circuit, but with no guidance by a given application context). This mismatch between the teacher's expectations and the courseware design was very detrimental to the courseware performance in this learning milieu. The courseware completion fall-off gradient was a little steeper than average for T1 and the steepest for all trials in all schools in T2. This was in spite of having more computers than in School B where the best performance was evident, having them sited

in the workshop to aid in courseware supervision and having demonstrably the most able children. This notable fall in performance from T1 to T2 indicated a loss of compliance with the teacher's practicality ethic and an opting-out of using the courseware by both him and his pupils. This was the only instance of a task type mismatch during T1 and T2 in all schools. In this instance the task type mismatch led to an over concentration on using the courseware as there was little else to do in the project. This over concentration caused hold-ups in the process and pupils to have to wait for excessive periods of time to use the computer. When coupled with the fact that there was no design agenda operating, because of the sub-type B task, pupils chose to opt-out of using the courseware and to complete the project by other means. This situation was magnified in T2 as the teacher became more aware of the failings of the courseware in his learning milieu. He was less willing to encourage his pupils to use it when they could achieve what he wanted them to do without it. Evidently a task match is a critical factor in whether the courseware will be successful and be adopted. If there is no willingness to engage in a type C task then using the courseware will have a detrimental effect on the learning milieu and opt-out will ensue.

If there is a willingness to engage in a type C task then the next most significant recurring feature in courseware success and adoption is the frame breadth match. This frame breadth match was not a significant feature in School A as the more significant task mismatch feature was operating. In both Schools B and C participating teachers commented on the ability of the courseware to support type C tasks with broader task frames than would have been previously possible. When this was the case they saw it as being beneficial to their learning milieux and a very positive outcome of using the courseware. Furthermore, in situations where the environmental factors were favourable, a frame breadth match lead to instances of less didactic teaching and feelings of greater control over the learning milieu where pupils were operating with high levels of procedural autonomy. This was particularly noticeable in two instances. Teacher A in School B had the highest levels of courseware completion across all trials in all schools. He is experienced, but was able to be less didactic in his teaching because

of the support provided by the courseware and he had one computer in use. Teacher C in School C had the highest levels of courseware completion in that school, She is inexperienced, but was able to support a type C task with high levels of pupil procedural autonomy because of the support provided by the courseware and she modified the physical environment such that she reduced the number of computers availble to support the courseware and situated them in her workshop.

There were no substantive instances of a frame breadth mismatch where the frame provided by the courseware was too wide, although Teacher A in School C did suggest that the frame should be narrowed for pupils of lower ability. However, this suggestion did not feature as a strategy in his own trial work across his three trial groups.

There was one instance of a task match and subsequent frame breadth mismatch where the frame provided by the courseare was too narrow. This was for Teacher B in School B. There were two components to the mismatch. The first component surfaced in T1 and was concerned with the extent of the courseware knowledge domain. In his previous work, Teacher B had used both thyristors and transistors in simple 3 stage control systems to provide pupils with a broader brief frame than the courseware allowed. However, he had used a narrower range of i/p and o/p components (cost and availability cited as reasons). The use of both thyristors and transistors in the project would significantly extend the courseware knowledge domain. Teacher A began T1 with an inappropriately wide brief frame as he has assumed that the courseware would be generic enough to support it. However, as the project progressed, and his familiarity with the courseware increased, he had to intervene in pupils' interactions with the courseware to adapt the content to support their needs in the best way possible. This intervention was revealed in the interview commentary and supported by a clump in the systems built profile around the most generic and adaptable input component (win/door switch). This intervention was costly in terms of time and caused the courseware to lose some compliance with his practicality ethic. He also cited some instances of the courseware contents adapting the project aims of his pupils. This adaptation by the

courseware relates more closely to the second component of the frame breadth mismatch, which emerged in T2, but also relates to a brief frame given by the teacher that is wider than the courseware can support.

The second component of the frame breadth mismatch, which emerged in T2, related to the specificity of the application context given as an example for the input componentry in C1. At the start of T2 Teacher B modified the brief that he gave to his pupils to match it more closely to the knowledge domian of the courseware. However, tensions then arose in the 'design' phase of C1. Teacher B was unsatisfied with the information given about the input componentry in C1 as he wanted it to be more generic. He felt that this information had similar effects to the problems indicated in T1 in that it either caused him to have to intervene when the example application context given did not closely match the agenda of the pupil using it or that it caused pupils to make abitrary changes to their project aims. This again caused a smaller though still marked clump in the systems built profile, ineffective use of teacher time, a fall in compliance with the teacher's practicality ethic and a resultant fall in courseware performance data.

There is evidently a relationship between the specificity of the given application context for the componentry and the looseness of the brief frame. This relationship relates to the information provided for the i/p and o/p componentry. In this courseware instantiation the information supplied for the o/p option relates only to what the component does, but not to what application or context it might be used for. In the case of the input componentry the information supplied tells the user what the component does, but also gives example applications in the form of a picture and, in the case of the microswitch and reed-switch, by the name that the system block that is given, i.e. window or door switch. Hence, the brief frame could be broadened by making this information more generic and less application specific. This generalising process may also have an effect upon the levels of heuristic interaction that pupils have with the courseware, which is discussed further at the end of this chapter.

In summary it appears that if there is a frame breadth mismatch, where the given frame is too narrow, brought about by the specificity of the information given in the 'design' phases of C1, then teacher intervention to modify the courseware content and opt-out, indicated by a fall in completion rates, will ensue.

If there is a willingness to engage in a type C task and there is a frame breadth match, then the next most significant recurring feature in courseware success and adoption is a match in teaching approach. This teaching approach match was not a significant feature in School A as the more significant task mismatch feature was operating. Nor was it a significant feature in School B. In School B Teacher A had a task and frame breadth match in both trials and reported that the courseware had enabled him to teach with a less didactic approach and with much greater levels of pupil procedural autonomy than if he had attempted a similarly framed task of this type; thus indicating a teaching approach change that brought the teacher and the courseware into congruence. It was not a significant feature for Teacher B as in both trials he had the more significant feature of a frame breadth mismatch.

In School C a teaching approach mismatch was evident for Teachers A and B and not for Teacher C. Teacher A's experience has led him to adopt a resource/capability model where he separates theory from practice and 'primes up' his pupils before they begin a design and make assignment, instead of using the project as a vehicle for delivering the theoretical content. Teacher B's experience has led her to adopt a largely linear process that is carefully recorded at each stage in the pupils' folders. Although the nature of these teaching approaches is different the motivations to adopt them are the same. They are both approaches that enable them to feel in control in what they perceive to be challenging learning millieux and, when the courseware is introduced into these millieux, they both cite loss of control as a result. Conversely, Teacher C had a teaching approach match and cited increased feelings of control when using the courseware. In T1 Teacher B invoked an access limitation strategy to regain feelings of control over the learning milieu. In T2 there were indications that Teacher A had reverted to his preferred

teaching approach, by getting pupils to take all of the decisions about what their system was before interacting with the courseware. This effectively removed any design or problem-solving agenda they might have taken to the courseware and, by realigning the use of the courseware with his preferred teaching approach, enhanced his feelings of control over the learning milieu. Although these two strategies resulted in enhanced feelings of control for the teachers, the result of both of them was to reduce the use of the courseware to a linear, information gathering exercise with no problem-solving interaction with the courseware. Teacher A had removed the problem solving agenda leaving his pupils little to do but collect the information they required to satisfy the decisions that they had already taken. Teacher B set up a situation where her pupils rushed through the courseware and in her words, "...did not explore enough". Hence, a teaching approach mismatch resulted in feelings of a loss of control over the learning milieu and the introduction of strategies to enhance fellings of control, which subsequently reduced pupils' heuristic interactions with the courseware.

The critical processes to emerge from the relationships between the task type, the frame breadth and the teaching approach when using the courseware are:

• There is a hierarchy in task, frame and teaching approach where task match is the most significant feature and teaching approach match is the least significant feature in courseware success and successful adoption.
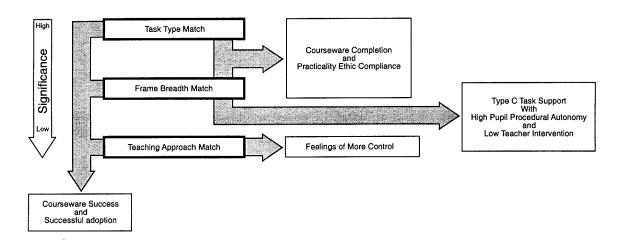
• Task and frame matches have the highest significance in the levels of courseware completion and compliance with a teacher's practicality ethic.

• Frame matches have a highest significance in the ability of the courseware to support a type C task with high levels of pupil procedural autonomy and low levels of teacher intervention.

• Teaching approach matches give teachers better feelings of control over the learning milieu when using the courseware.

• Strategies to enhance feelings of control when a teaching approach mismatch occurs
reduce pupils' heuristic interactions with the courseware (shown as component of
Critical process 4).

Critical Process 3 - Task, Frame and Teaching Approach Hierarchy

Fig. 142
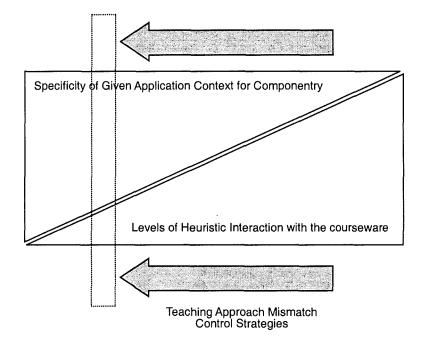
The courseware data showed low levels of heuristic interaction in all trials and in all
schools. It is evident from this discussion of the task/pedagogy features that a critical
process relating to heuristic interaction is emerging. This discussion has already
identified the relationship between the specificity of the given application context for
the componentry and the breadth of the brief frame and the ability to broaden the frame
by making this information more generic and less application specific. This element of
the discussion was brought about by the frame breadth mismatch for Teacher B in
School B. This trial indicated that the specificity of the information provided had, in
some cases, either required him to intervene to modify the courseware content to suit
the design agenda brough to the courseware by his pupils, or that the information
provided by the courseware had caused pupils to make arbitrary changes to their design

aims. In all other trials this information was not seen to be problematic, but this may be indicative of the level of design engagement that pupils had had with the project before accessing the courseware. If no design agenda had been established before interaction with the courseware began, or this agenda was only loosely focused, then subsequent design decisions would be based on the content of the courseware and this would necessarily be satisfactory in scope and range. Likewise if the design agenda had been effectively removed by the teacher ensuring that all possible decisions had been taken by pupils before they began their interactions with the courseware, and the design decisions taken were the same as those facilitated by the courseware, then again the information provided by the courseware would be satisfactory in both scope and range. However, if a design agenda had been established before the pupils began their interactions with the courseware and the decisions that they had taken were germane to both the task and frame that the courseware is designed to support, but not the actual content of the courseware, then the specificity of the application context surrounding the information that is provided could lead to the problems highlighted by Teacher B in School B and also lead to low levels of heuristic interaction with the courseware. A reduction in the specificity of the application context for this information, i.e. making it more generic, is likely to lead to greater levels of heuristic interaction as pupils find, compare and select information that is most appropriate to their project application context rather than the exemplar provided by the courseware. Such a change would also enable the courseware to stimulate heuristic interaction in learning milieux where no design agenda had been established before the pupils began interactions with the courseware. This change would also reduce the possibility of the courseware causing pupils to make arbitrary rather than reasoned modifications to their project on the basis of the information that it supplies. However, such a change would not overcome the difficulties observed when teachers invoke strategies to overcome a teaching approach mismatch. In the trials, such strategies were related to teachers regaining control that they had lost due to a teaching approach mismatch. It is unlikely that any modifications to courseware of this type could overcome these difficulties and stimulate heuristic

interactions, when it is these kinds of interactions that are associated with a perceived loss of control when a teaching approach mismatch is evident.

The critical process to emerge from this relationship between the specificity of the given application context for the componentry, strategies brought about by a teaching approach mismatch and levels of heuristic interaction with the courseware can be expressed thus: there will be a rise in heuristic interaction as the specificity of the given application context reduces, but strategies invoked by teachers to enhance their feelings of control in learning milieux where there is a teaching approach mismatch will put a bar on how far those heuristic interactions can proceed. The relative position of the bar will relate to the nature of the strategies invoked.

Critical Process 4 - Heuristic Courseware Interaction

Teaching Approach Mismatch
Control Strategies

Fig. 143

Chapter 6 - Recommendations for the Next Courseware Iteration

From the courseware trial and evaluation phases described in chapters 4 and 5 of this current research project, three major themes have emerged that relate to further development in both courseware content and operation in subsequent iterations. Two of these themes relate to courseware control - 'getting back' and concurrent visit strategies for cluster 2 (C2-CV), and one which relates to courseware content - the level of information specificity or generality in system blocks (principally the input block).

Courseware Control - Cluster Transition and 'getting back'

The first iteration of the courseware was guided by the instantiation process developed in Chapter 2 of this current research project viz:

1. Break the overall task down into task stages that can be facilitated by a cognition cluster.

2. Begin 'growing' the cluster by:

a. specifying the nature of the excursions that will be made available from each stage node;

b. specifying the nature of orientation nodes that will be made available on repeat visits to a stage node;

c. formulating the criteria that will enable transfer from one stage to the next.

3. Build the courseware by sequencing the cognition clusters and decide whether the inter cluster links are mono or bidirectional.

4. Decide upon how the intelligence outcome might be manifested and where and what intelligence income will need to be sought.

The high levels of reported success, typified by teacher adoption of the courseware for the second trial and instances of teacher stated improvements to the learning milieux during the trials where the factors controlled by the critical processes were favourable, validate this courseware development paradigm and instantiation process. However, it is evident from the recurring theme of problems 'getting back', even in situations where the factors controlled by the critical processes were favourable, that some further development of, or an additional component to, this instantiation process is required. There were no significant features that had a recurring concomitance with these cluster control problems, indicating an independence from the range of learning milieux experienced in the trials. However, it was noted that the incidence of redemption, the pupil activity associated with overcoming problems 'getting back', became more prevalent as computer time became more plentiful. This increase in redemption was related to the viability of this strategy in relationship to the availability of computer time.

There were two principle reasons for the inclusion of cluster transition control mechanisms (instantiation process 2 [c] and 3). The first was as a physical instance of the notional guided discovery mechanism that the courseware was to provide. The second was to minimise on poggling in situations where computer time was limited. However, from the evidence provided by the trials, there are strong indications that poggling is least prevalent in learning milieu where computer time is limited, which effectively negates this design criteria assertion.

These observations indicate that, although the cluster transition control mechanisms are a useful component of the overall guided discovery mechanism provided by the

courseware, there are instances when they may need to be overridden. However, any

courseware control feature that enables the cluster transition control mechanisms to be

overridden should not compromise either the guided discovery mechanism or the

integrity of the user model. It is evident that these criteria might be satisfied by some

form of dynamic, cluster-focused, courseware map, where the clusters are presented as

'sub-headings' in the project 'chapter'. Such a map would enable the user to gain a

macro-level overview of the courseware structure and its dynamic content would enable

them to see their progress through it. This proposed additional feature would be

generated at point 5 of the instantiation process; its static content being specified by the

courseware developer and its dynamic content being an intelligence outcome, updated

by the system and guided by the user model. There are three possible 'positions' that the

map might take and each of these would be dependent upon system capability and have

the potential to affect users' interactions with the courseware differently. These three

positions would either be:

• as a 'front-end' to the courseware whereby users' access to the knowledge domain is

through the dynamically updated map;

• as an over-arching mechanism, accessed via a floating window, that would enable

users to jump out of their resident cluster into another;

• as a 'back-end' to the courseware whereby the map is accessed from any card, or from

key navigational way-points', in the courseware and is called for by the user.

As a front-end the map would create no significant overhead on system resources, but

would potentially have a significant impact on users' interactions with the courseware.

The resultant courseware would retain an implicit element of guidance, but this would

principally be provided by the dynamically updated map, and, as a consequence, the

level of guidance would be significantly reduced. The guided discovery mechanism is a

principal element of the courseware development paradigm that resulted from this

current research project. Removing it, or reducing it to the point of ineffectiveness,

would open up this hypermedia corpus to those problems associated with disorientation in hyperspaces and would also negate the unique ability of the courseware to traverse the continuum of courseware design approaches in the satisfaction of design and make activities (hierarchical, hypermedia, linear used to select, investigate and operationalise).

As an over-arching mechanism the map would create a significant system overhead. It would require the use of an extra window and would also require the system to both respond to, and update the content within, both windows simultaneously. The level of computer technology in School C would have been more than adequate to support this, but the computers in Schools A and B would have been severely stretched. This consideration should not form a significant component of the selection criteria for this map 'position' as it will become negligible as improved computer technology filters down to schools. However, the reservations regarding users interactions with the courseware discussed with a front-end map would also be evident in this map 'position', but would be further amplified. Not only could users make massive leaps through hyperspace at the beginning of their courseware visits, but they could also make similar leaps at any time during their visits. Such a map position would effectively negate all of the unique features of this courseware development paradigm associated with the effective support of task focused, goal oriented learning milieux.

As a back-end the map would create no significant overhead on system resources, but would potentially have some impact on users' interactions with the courseware, although this option would be least disruptive to the courseware operation. The typical range of interactions with the courseware, and the influence of the guided discovery mechanism, would be left unchanged until a user calls for the map from a point in the courseware. The level of potential disruption, and its associated effects of user disorientation, could be minimised by limiting map access points to the key nodes in each cluster, where the courseware is in a hierarchical mode. Although this back-end option appears to be the most suitable in this context, it is evident that the increased

level of user control afforded by the addition of this feature still has the potential to compromise the integrity of the courseware.

The purpose of including a dynamic map is to enable users to revisit key aspects of the courseware content after cluster transition has been made and, in this current instantiation, the problems are associated with transition from C2 to C3 and C3 to C4. The content of this intelligent hypermedia corpus can be arranged and presented in different ways by the system and, hence, it is the intelligence of the system itself that could be used to realign the balance of control between system user and system, and to avoid the potential pit-falls of this additional level of functionality. What this position advocates is using the system intelligence not only as a mechanism to dynamically update the map, but also as a tool to invest the map with the similar level of intelligence as the courseware itself; the resultant outcome being a 'map' that can engage in meaningful dialogue in a context related, user focused manner. Such a map would still be called from the key hierarchical nodes in each cluster, but instead of being confronted with the equivalent of a user controlled hyperspace teleport terminal, users would engage in dialogue with a personal travel consultant who could also be their guide. This level of courseware interaction would ensure that users find the key information that they require and could return successfully to the point at which they called the map into operation. The level of dialogue required would be relatively easy to support via context related options presented by the system, some of which might be further divided by the appropriate level of sub-options; essentially a hierarchical decision-tree, where the form and content of the tree would be decided by the system intelligence and be informed by the user model as an intelligence outcome. There would be no necessity to gain an intelligence income from users' interactions during these 'redemption' activities as all material would be presented by the system, as an outcome of the dialogue, and would not have an impact upon normal cluster operation. Hence, the user model would retain its integrity and the guided discovery mechanism would not be compromised by this additional level of courseware functionality. However, the intelligent support offered by this facility could also enable modification of the circuit

configuration (C1 activity focus) after the transition from C2 to C3 has been made. Up until this point of transition the facility to modify the circuit configuration is available from C2, but once the C2 to C3 transition has been made there are no further opportunities to modify it. This modification option would require intelligence income to be sought to modify the user model and, by the system's use of this modified user model, the modification to the circuit configuration, and the requirement to visit new areas of the knowledge domain, would 'ripple through' to the users' subsequent interactions with the courseware. Such a 'ripple-through' might initially manifest itself as a backward cluster transition by one or more clusters. However, the potential for disorientation would be minimised by the guided discovery mechanism retaining its functionality and influence.

Formulating the option types, sub-levels and availability would be a process of rule-based extrapolation from the user model data by the system:

1. Establish cluster residency - options should only enable access to key content from previously visited clusters.
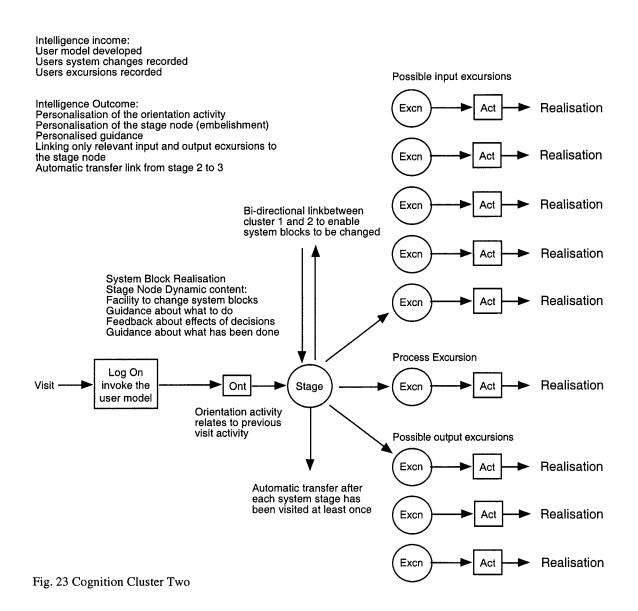
2. Establish point of cluster residency - options should only enable access to key content from previous visits to the resident cluster. This would be possible via normal interactions with the courseware, but could be provided as an extra facility for little overhead.

3. Establish interaction types to be provided - options should provide paths to key information, but not enable changes that would compromise the integrity of the user model, e.g. changes to circuit configuration in C1, unless the necessary intelligence income can be sought and applied to the user model.

4. Establish information types to be provided, e.g. facility to reprint information, facility to rehearse visit portions, etc.

Courseware Control - (C2-CV)

In this current courseware instantiation Cluster 2 (C2) is where information about the

three circuit stages is accessed. Users can visit the stages as many times as they feel is

necessary and they may also modify the circuit configuration by revisiting Cluster 1

from the main C2 node. Transition from C2 to C3 is automatic and occurs once all three

stages have been visited at least once. Hence, C2 is minimum three visit cluster with a

bi-directional link to C1 and an omnidirectional, automatic link to C3. Fig. XX is

reproduced here for information.

Intelligence income:
User model developed
Users system changes recorded
Users excursions recorded

Possible input excursions

Intelligence Outcome:
Personalisation of the orientation activity
Personalisation of the stage node (embelishment)
Personalised guidance
Linking only relevant input and output ecxursions to
the stage node
Automatic transfer link from stage 2 to 3

Bi-directional linkbetween
cluster 1 and 2 to enable
system blocks to be changed

System Block Realisation
Stage Node Dynamic content:
Facility to change system blocks
Guidance about what to do
Feedback about effects of decisions
Guidance about what has been done

Visit

Log On
invoke the
user model

Ont

Stage

Orientation activity
relates to previous
visit activity

Process Excursion

Possible output excursions

Automatic transfer after
each system stage has
been visited at least once

Excn → Act → Realisation
Excn → Act → Realisation
Excn → Act → Realisation
Excn → Act → Realisation
Excn → Act → Realisation
Excn → Act → Realisation
Excn → Act → Realisation
Excn → Act → Realisation
Excn → Act → Realisation

Fig. 23 Cognition Cluster Two

A key feature of normal courseware interaction is that users undertake practical activity

between their visits to the courseware. Subsequent visits that take place immediately

after the previous visit was completed, i.e. in the same computer use time-frame, have

been termed as 'concurrent visits' and can be seen as deviant behaviour. There were a

variety of levels of congruence with regard to visit frequency and the courseware design

intent across the trials and the individual instances have been discussed in Chapters 4

and 5. However, stimulus to re-evaluate the control features of C2 was gained from the

trials in School B. This is where the courseware was most successful in terms of

supporting a learning milieu with a type C task in operation and with relatively high

levels of pupil procedural autonomy. The trials in school B were also the most

successful in terms of pupil engagement with the courseware. There was a task, frame

and teaching approach match experienced by Teacher A in T1 and the situation based

features were largely favourable. However, when the data regarding visit concurrency

by cluster was examined it became apparent that Teacher A had encouraged his pupils to

adopt a deviant concurrent visit strategy during C2 and a congruent NS/SS strategy

during the other clusters. This is shown by the rise in the CV component of the visit

concurrency by cluster profile during C2 and its subsequent fall in C3.

	C1 to C2	C2	C2 to C3
CV	16%	46%	24%
SS	11%	19%	0%
NS	74%	35%	76%

Fig. 144
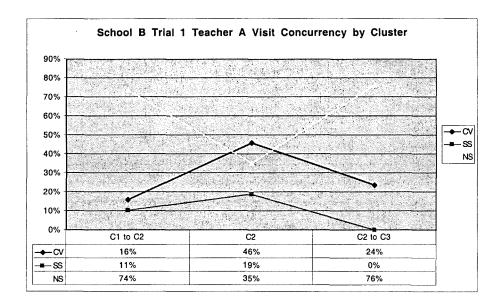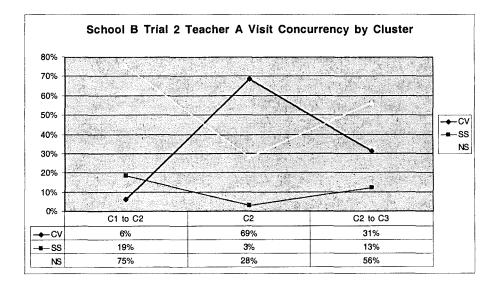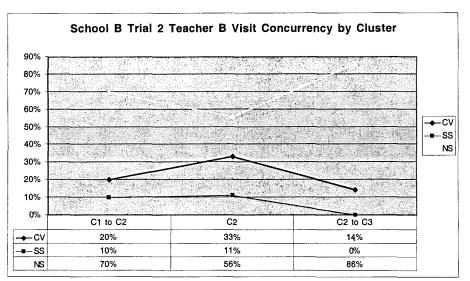
This strategy, termed as C2-CV was repeated by Teacher A in T2 and it became more pronounced. Alongside this amplification of the trend the levels of courseware completion rose to 100%. Furthermore, there were no indications that this strategy had been adopted in T1 by Teacher B, but there are indications that there was some filter-through to either himself or to his pupils as the C2-CV trend is apparent in his profile for T2. It is at a much lower level and other critical processes (frame mismatch) caused the performance for his group to fall during this time. Nevertheless, these profiles indicate that when computer time is limited, and the critical processes operating are favourable, a C2-CV strategy can enable high levels of courseware completion to be achieved.

School B Trial 2 Teacher A Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
—◆—CV	6%	69%	31%
—■—SS	19%	3%	13%
NS	75%	28%	56%

School B Trial 2 Teacher B Visit Concurrency by Cluster

	C1 to C2	C2	C2 to C3
—◆—CV	20%	33%	14%
—■—SS	10%	11%	0%
NS	70%	56%	86%

Fig. 145
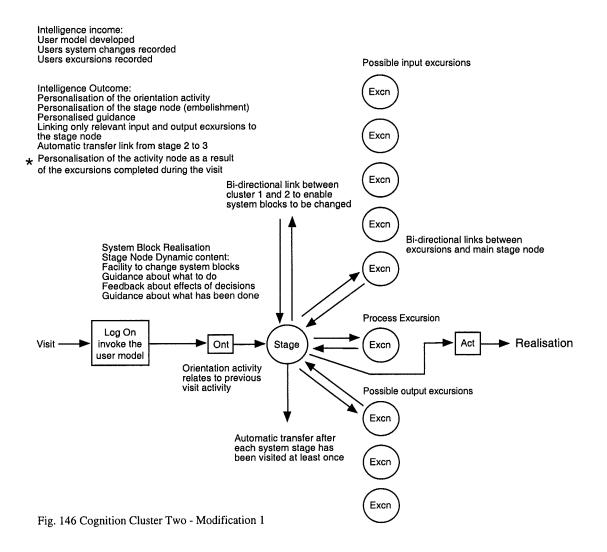
Further indications that Cluster 2 might be better delivered in one visit were provided by Teacher B in School C. She indicated that she had invoked a C2-CV strategy during the T1 interview, but this was effectively masked in the courseware data by an exceptionally high level of CVs in the overall profile. However, in some situations it may be appropriate that C2 can still be completed in a number of visits as the time taken to complete it would increase three fold and the amount of practical work to manage would increase by a similar rate. In light of these factors it is evident that the structure of C2 should be modified to enable meaningful completion in either one or more visits. This modification could be achieved in a number of ways, but whichever is chosen it is important that the operation of the courseware remains coherent, in that the visit end points remain clear, to prevent aimless wandering. Two possible solutions are evident when the structure of C2 is re-examined.

The first would be to sever the links from the excursions to the activity nodes and to instantiate a bidirectional link between the excursions and the main stage node. This would cause the main stage node to become the exit point from the cluster into the practical activities. A single dynamic activity node would be accessed from the main stage node when the user elects to exit the cluster. The system would provide the content for this node as an intelligence outcome and it would detail the necessary practical activities as a result of the excursions completed.

Intelligence income:
User model developed
Users system changes recorded
Users excursions recorded

Possible input excursions

Intelligence Outcome:
Personalisation of the orientation activity
Personalisation of the stage node (embelishment)
Personalised guidance
Linking only relevant input and output ecxursions to
the stage node
Automatic transfer link from stage 2 to 3
* Personalisation of the activity node as a result
of the excursions completed during the visit

Excn

Excn

Excn

Bi-directional link between
cluster 1 and 2 to enable
system blocks to be changed

Excn

Excn

Bi-directional links between
excursions and main stage node

System Block Realisation
Stage Node Dynamic content:
Facility to change system blocks
Guidance about what to do
Feedback about effects of decisions
Guidance about what has been done

Excn

Process Excursion

Log On
invoke the
user model

Visit

Ont

Stage

Excn

Act

Realisation

Orientation activity
relates to previous
visit activity

Possible output excursions

Automatic transfer after
each system stage has
been visited at least once

Excn

Excn

Fig. 146 Cognition Cluster Two - Modification 1

Excn

This proposed change would satisfy the modification criteria in that the cluster could be completed in one or more visits and the exit points and associated practical activities would remain clear. However, the system overhead to construct the contents of the activity node would be relatively high and it may become necessary to provide this information on more than one screen if the excursion count rose past a certain level.

The second modification option would be to leave the excursion and activity structure unchanged, but would provide an optional looping link back to the main stage node from the activity nodes. This change would again locate a new exit point in the main stage node, but would also retain the exit points at the activity nodes.

Intelligence income:
User model developed
Users system changes recorded
Users excursions recorded

Intelligence Outcome:
Personalisation of the orientation activity
Personalisation of the stage node (embelishment)
Personalised guidance
Linking only relevant input and output ecursions to
the stage node
Automatic transfer link from stage 2 to 3

Possible input excursions

Excn → Act → Realisation

Excn → Act → Realisation

Excn → Act → Realisation

Excn → Act → Realisation

Excn → Act → Realisation

Bi-directional linkbetween
cluster 1 and 2 to enable
system blocks to be changed

System Block Realisation
Stage Node Dynamic content:
Facility to change system blocks
Guidance about what to do
Feedback about effects of decisions
Guidance about what has been done

Process Excursion

Excn → Act → Realisation
→ Realisation

Visit → Log On invoke the user model → Ont → Stage

Orientation activity
relates to previous
visit activity

Possible output excursions

Excn → Act → Realisation

Automatic transfer after
each system stage has
been visited at least once

Excn → Act → Realisation

Excn → Act → Realisation

Fig. 147 Cognition Cluster Two - Modification 2

This second option would have no significant system overhead and would maintain coherence and clarity in relation to the exit points. Furthermore, as the three circuit activity nodes would remain separate, their content could be more easily revisited, or reconstructed by the system, for redemption purposes via the intelligent, dynamic map proposed above. For these reasons modification option two would be preferable.

Courseware Content - Application Specificity

Critical Process 4 (CP4) from this current research defines the link between heuristic courseware interaction and the levels of specificity of the application context given for the electronic componentry, particularly in relationship to the input excursions in C1. It is evident that heuristic interaction would be stimulated if the information in these nodes were more generic. However, if a blanket generalising process were applied then the commensurate increase in frame breadth is likely to cause further application of teacher invoked control strategies in learning milieux where there is a teaching approach mismatch. Control strategies such as these effectively negate the potential for heuristic approaches to the courseware. This is essentially the process defined by CP4. Overcoming the 'bar' applied in CP4 by these control strategies, and the problems of arbitrary project aim change brought about by overly specific information, might be possible by increasing the scope and range of the information available and layering it in the C1 input decision nodes. This layering process would enable users to investigate a particular circuit configuration from a generic viewpoint. Continuing along the information trail would present information in an ever more context specific manner, which may result in application contexts being indicated. However, it would be of benefit to supply more than one example of how the circuit configuration could be applied to stimulate thought on how it might be applied to the application context that is specific to the user. This approach does not advocate a further level of hierarchy, immediately beneath the main system node of C1, used to select and investigate an example application context. This approach would show the same potential for pitfalls as the unmodified C1. However, a hierarchically organised set of example application contexts, which apply the previously supplied generic information to show how the circuit configuration operates in the application context may be successful.

This proposed modification for C1 would extend the knowledge domain, but would have no significant system overhead. In many ways it is a re-sequencing of the extant knowledge domain. In its current form the courseware supplies generic information in

C2 after the initial design decisions have been made in C1. Users have the opportunity to change their decisions in light of their experience in C2, but the data shows that very few of them were either willing to do so, or were not engaging with the courseware at this mental level. Moreover, the majority of users either view the information for one input component, suggesting a completely resolved or non-existent design agenda, or they look at all five, suggesting a browsing approach and no specific design agenda. Extending the knowledge domain in the ways discussed and re-sequencing the presentation of information could stimulate the desired heuristic approach to using the courseware as there would be a greater scope for making design decisions based upon the expanded knowledge domain and its organisation would demand this level of engagement.

It is evident that although CP4 relates to heuristic interaction, and this proposed modification is a response to it, there may be other critical processes operating that were beyond the scope of this current research project. The similarity of all of the design visit profiles in all trials, in all schools, and their variance with the expected profiles is worthy of further investigation and may be due to as yet unidentified critical processes which are common to learners rather than particular to specific learning milieux. This opportunity for further study is discussed more in Chapter 7.

Chapter 7 - Conclusions and Recommendations for Further Work

Overview

When reflecting on this research project it is salient to return to the friendly warning provided by Phillips and Pugh (page 50). This research project did indeed require the discovery of original problem solutions by bringing together intellectual resources from a number of disciplines. This research project was divided into a number of major phases: designing the courseware development paradigm; instantiating the courseware; developing the data extraction tools; collecting and analysing the data from the trials.

Researchers who propose to engage in the individual author prototyping of courseware should be under no illusions as to the complexity of generating even the most basic of hypermedia domains, and particularly so when these are to be supported by system intelligence. The current version of the courseware contains over 300 nodes and when the hyperTalk scripts are extracted they run to over 63,000 words. Although some 'cutting and pasting' was possible, the production of screen graphics, the development and keying in of scripts and the testing and debugging of the results is a significant undertaking that should not be entered into without careful consideration of the time necessary to complete the work. However, there were invaluable learning outcomes to be gained from this process. This thesis will enable others to gain a better understanding the complexity of courseware design and instantiation for task driven, goal oriented situations such as Design and Technology education. It will enable others to be better placed to undertake collaborations with computer scientists and software engineers in similar courseware development projects.

Adopting the process of individual author prototyping made it possible to build the

basic data extraction tools, and to subsequently develop them as the data was

considered. Deploying an illuminative evaluation method requires this level of

flexibility in the data analysis tools as themes emerge through the interview transcripts,

through the significant features of the trials and through the recurring concomitants

across the trials. By having ready control of the data extraction tools it was possible to

respond to these themes by extracting the data in a variety of forms prior to its analysis.

It should be recognised again that such an undertaking can involve the researcher in

considerable amounts of work, but that the data gained from the courseware user models

has been invaluable in triangulating the interview responses and in suffusing them with

a quantitative underpinning. The research could have focused on the 30,000 words of

interview transcripts, but the outcomes of this research project would then have been

fundamentally flawed as a result. If a purely qualitative evaluation approach had been

undertaken, via the analysis of the interview transcripts, then a very different picture

would have emerged. The majority of teachers reported very positive responses to the

courseware, but the courseware data was able to provide an analytical insight that, in

some instances, clearly indicated differences. Moreover, the critical processes identified

would not have emerged had this quantitative data been unavailable. Likewise the

quantitative indicators of relative performance, provided by the courseware data, would

have had little meaning without the significant features provided by the teachers'

reflective accounts contained in the interview transcripts.

In the data extraction and analysis phase it was necessary to work with sets of data from

45 individual computers across both trials in the three schools. This process required the

translation of the extracted data into forms that could be analysed using spreadsheets.

Once complete the data sets held on the spreadsheets enabled trial group norms and trial

averages to be formulated, which were invaluable aids in the collaborative analysis,

which was needed to assess relative performance. There was a possibility that the

research might have become swamped as each new theme to emerge necessitated a

modification to the data extraction tools or addition to the spreadsheets holding the data

sets. However, focus was maintained by continuing reference to the research question and the courseware design specification. The clarity that the data reveals and the emergence and interpretation of previously unrecognised phenomena justified the data collecting and analysis procedures.

In summary, this research project has been extended to an extent that was not fully envisaged at the outset, but has confirmed the importance of both the notion and practice of triangulation in 'messy' situations that cross academic disciplines.

Project Methodology

The project methodology that was developed for this current research by the synthesis of approaches from individuals from different disciplines has been very successful in both instantiating the courseware prototype and gaining an understanding of its efficacy and effects in the trial learning milieux.

Individual author prototyping enabled a relatively rapid instantiation of the prototype, which did not fall prey to 'losing its way' as a result of misunderstandings between, and aim modification by, a number of potential contributors. Rapid and productive changes to the prototype were feasible as a direct result of user testing. This kind of iterative approach, guided by feedback elicited from users, is central to the success of courseware as it challenges or affirms the assumptions that are made by the developer at each stage of the development. The process of gradually increasing the influence of personal and situational variables as the prototype emerged brought a productive focus to issues as the prototype developed and enabled the development process to respond to feedback without falling prey to the potential weight of feedback that is available in highly naturalistic settings; a micro to macro view that is supportive in an iterative interaction and domain building exercise.

The pilot phase, undertaken in one school, was critical in confirming the integrity of the

courseware and its ability to perform in a real learning milieu. It stood up well to the 'prodding' and 'poking' that these first pupils gave it and the resulting data collected enabled the development of the data extraction tools, and any associated aspects of the user model construction process to be modified, before the main study began. Working with this teacher in the pilot study also stimulated the development of the teachers' report utilities in the 'hyperTeacher' node; a level of functionality that was not part of the original design criteria and that is a good example of how developers can benefit from eliciting feedback from curriculum providers.

It has to be recognised that relying on teachers to adopt the courseware to complete the second trial iteration, necessary to provide the required depth in the analysis, was a risky, but realistic research strategy. If no teachers had been willing to adopt the courseware then the evaluation would have been limited. However, if this situation had arisen it would be indicative of some major problems with the courseware and could potentially have been used as a basis for an early iteration to overcome these issues. This initial rejection would have extended the project time-scale as the adoptive trial phase seems to be critical in breaking through the organisational concerns that are paramount when a new resource is introduced into the learning milieu. Research of this type requires great effort by the willing, participating teachers as well as the enthusiastic researcher. Researchers should be sensitive to the 'practicality ethic' of the participants even though it may not always be possible to achieve compliance with it.

Analytical Method

The efficacy of the analytical method has already been alluded to in the introduction to this chapter. The combination of the flexibility in extracted data forms, brought about by the ability to build and develop the extraction tools, and the functionality of a typical spreadsheet package in providing analytical interpretations of this data, enabled the essentially qualitative significant features identified in the interview transcripts to be triangulated against a number of quantitative indicators. Although this analytical method was time consuming to execute and relatively organic and evolutionary in form, it

embodies the key concepts of illuminative evaluation methods, which require research

instruments that can observe, inquire into and provide possible explanations of, the

complex set of circumstances that structure and interact in a learning milieu. It is the

complexity of these circumstances, and the unpredictable nature of their interactions,

that demand flexibility in the deployment of the analytical method. Productivity in the

data analysis would be improved by some pre-specification of the themes to be explored

and in some senses this is possible and was done. However, illumination demands

flexibility and quantitative instruments must respect this need for flexibility. It is evident

that the data extraction tools are particular to this research project, to the courseware

that they have been designed to extract the data from and to the functional requirements

of this researcher. They could not be directly deployed by other researchers in other

contexts. However, the underlying principles that informed their development may

prove to be useful for some in highlighting the role of user model data in both informing

the intelligence outcomes of courseware and as a source of data in similar illuminative

studies.

Efficacy of the courseware

It is evident that both the courseware development paradigm and the subsequent first

instantiation of a courseware prototype have been successful in achieving their aims.

The courseware is a positive asset to teachers and pupils by being effective in

supporting Type C tasks, which demand relatively high levels of pupil procedural

autonomy; the essential ingredients of Design and Technology education. Teachers are

able to pass control of the project to their pupils through the courseware to levels that

are appropriate to their developing capability. However, this success relies upon the

critical processes identified in chapter 5 being favourable. These critical processes are

informed by the concomitant features from each trial, which indicate how the significant

features from the trials affected the particpating teachers' opinions and use of the

courseware.

Critical processes 1 and 2, which relate to the physical environment, are relatively easy to control once they are understood as they simply rely upon the position and management of the learning resources.

Critical process 3 is more problematic as it relates to applied pedagogy. This courseware prototype has been designed to support a particular form of applied pedagogy and when this applied pedagogy is evident in the learning milieu it is very successful in supporting it. If there is a mismatch in any of the three principal components of the applied pedagogy (Task, frame, approach) then the mismatch will have a detrimental effect on the performance of the courseware and, by association, the productiveness of the learning milieu. The courseware is not universal, nor should it be expected to be, as it was designed with specific aims in mind. It is difficult to envisage how critical process 3 could be overcome by redesigning the courseware. In many senses critical process 3 illuminates a potential deficiency in applied pedagogy, when the aims of Design and Technology education are considered, rather than a deficiency in the courseware design.

Critical process 4 relates to heuristic interaction with the courseware. This outcomes of this research project have indicated that an element of this critical process relates to a mismatch in applied pedagogy. However, in situations where there was a clear and direct match in applied pedagogy, and critical processes 1 and 2 were also largely favourable, levels of heuristic interaction with the courseware were still low. Further understanding of critical process 4 and the potential to stimulate higher levels of heuristic interaction can only come from further study. Opportunities for this further study are discussed later in this chapter.

Contribution

This research project makes claim to the following substantive contributions to knowledge:

• In attempting to solve the real-world problem of developing courseware that can support teachers and pupils in task-driven, goal-oriented learning milieux, where pupils

undertake task types that demand relatively high levels of procedural autonomy when compared to other task types, a new courseware development paradigm has been designed, viz:

The sequential combination of cognition clusters, supported by system intelligence, derived from a dynamic user model.

• In trialing a courseware prototype, that has been instantiated under the guidance of this new courseware development paradigm, an understanding of the critical processes that affect its efficacy in a small range of learning milieux has been gained. The range of trial scenarios was too small for the outcomes to be generalised to any significant extent. However, the critical processes that emerged from the trials can be related to other learning milieux with similar features.

Recommendations for further work

From Prototype to Product

There were a number of other courseware development opportunities identified through the experience of instantiating the courseware and conducting the trials that do not relate to the recurring concomitants and critical processes, but which are more concerned with the issues associated with progressing the courseware from a prototype to a useable product. These include: the relationship between the content and structure of the courseware; the requirement for robustness in courseware prototypes and products; the distribution of the user model, via network technologies, to achieve courseware portability and machine independence.

The Relationship Between Content and Structure

This courseware development paradigm demands that certain structural elements are formulated in relation to the cognition clusters before the content is generated and, as

the level of intelligence increases, there is an increase in the instances of content being required to be 'recalled' by the system without it affecting the user model, e.g. in the fault finding domain, in the proposed intelligent, dynamic map, etc. In this first courseware prototype there are many instances where the mechanisms to gather intelligence income were embedded in the nodes and, hence, many of these nodes could not be recalled in their initial state for other purposes without compromising the intelligence income and the user model. Duplicating information content for different purposes is costly in terms of development time and system overhead. It is evident that moves should be made to separate the content of the courseware (the knowledge base) from the structure of the courseware (the cluster features and system intelligence). Such a move would enable generic content to be supplied that could be used in a variety of contexts throughout the courseware. Although this development is theoretically possible with the chosen development platform (hyperCard running on an Apple Macintosh) it is not the most suitable. What appears to be required is a relational database that is interrogated by the users' interactions with screen objects, and where object presentation is governed by a master control script. The nodes could then be populated by place-holders for text strings, graphics and buttons. Such a system would enable a massive reduction in the number of nodes and could utilise generic content from within the database. Developing the courseware would become more of an object oriented development exercise and less of an 'authoring' experience. Furthermore, courseware generated in this manner could be 'repurposed' by simply changing the master control script and so alleviate the need to generate fresh on-screen content for each node. This separation of content and structure, essentially the look and feel, is becoming common practice amongst developers of larger web sites. Both the look and the feel of sites can be changed independently and rapidly. Content can be used for differing circumstances and more recently for differing users. Under the influence of this development approach web sites are now even exhibiting some forms of intelligence in the way that they can present content differently according to the user of the site. This intelligent response to the user is presently used as a marketing tool (Amazon is currently a prime example),

but is yet to filter through to educational resources. These remain as relatively 'dumb' technologies where the only level of personalisation comes through human interaction via email and conferencing utilities.

Increase the Robustness of the courseware

The courseware prototype is vulnerable to misuse by its users who, under certain circumstances, have been able to corrupt the user model. The integrity of the user model is a critical component of the courseware as the cluster control mechanisms rely upon it to provide personalised content in coherent and productive sequences. This vulnerability has been guarded against by using a number of strategies that are described and detailed in section 3 of chapter 3. However, one critical weakness remains in the prototype and that is the effect of incomplete visits resulting from prematurely switching off the computer or rebooting it during a visit. Critical process 1 explains why and when this type of deviant behaviour occurred during the trials. The vulnerability to this form of 'attack' is brought about by the process of user model construction by the courseware. The majority of the user model is written as the user logs-off from the system as it is at that point that a decision has been made. However, it is evident that this in an under developed strategy that is worthy of further research. What emerges is the need to modify the log-on algorithm so that if the courseware encounters an incomplete user model upon its invocation, it can consult the user's path card data and return them to the point at which they left off. Robustness of intelligent courseware prototypes and products should be a key consideration in future work.

Network the user model

The current courseware prototype has no network functionality. However, during the course of this research project there has been something of an explosion in network technology and increasing levels of functionality have been afforded to the web. Web based technologies are now sufficiently developed to enable courseware of this type to
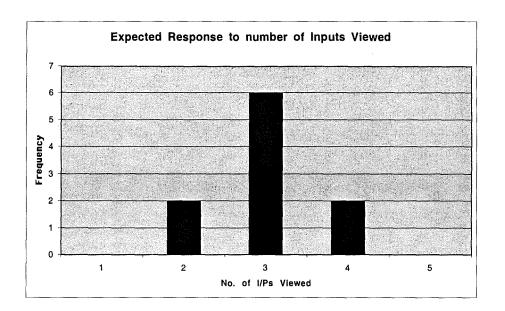
become web accessible and, hence, completely portable and machine independent. It may be that network speed is still currently an issue that could prevent this development, although network bandwidth availability continues to increase at a healthy rate. Furthermore, web based technologies are deployable at an intranet level, which is a possible interim strategy. It is evident that the courseware development paradigm is 'portable' and could be readily used to develop web based courseware. This has to be the foreseeable future of intelligent courseware. Presently the web has had the same influence on educational resources as that observed on the introduction of CD-Roms as the technology is essentially the same. Knee-jerk constructivism by time-pressed and commercially motivated developers, domains that are all but impossible to navigate, little indication to users of how much material the domain contains, lack of task direction and style over content are still present, but the difficulties are exacerbated by the extreme fluidity of web based content - little stays the same for long on the web. It may be that in the near future the 'computer' may disappear from our desktops and be replaced by new devices brought about by the continuing miniaturisation of electronic and communications technologies. However, it is likely that networks will continue to be a major feature of the functionality of the present and future information products. It is imperative that courseware developers overcome the pressures to respond simply to new technology as the pace of technological change is unlikely to decline. The persistence of educational tools that are less effective than the books that they seek to replace are in danger of being rejected by their users. Unless it is sensitively and coherently authored, to become a positive asset to its end users, courseware is in distinct danger of becoming the 'digital watch' of the early 21st century.

Heuristic Interaction
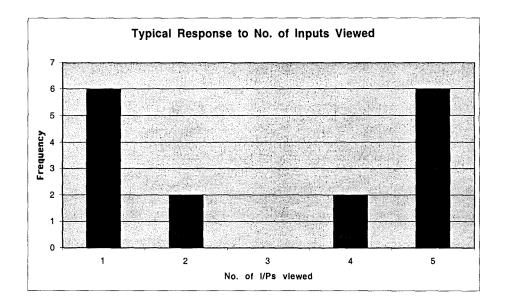
Courseware that stimulates users to interact with it on a heuristic level is a key feature that can elevate it above traditional texts. However, although there were favourable qualitative indicators from the participating teachers, the quantitative indicators show that this courseware prototype has failed to achieve this to any significant extent.

Critical process 4 is a starting point in understanding why this current prototype has failed in this area, but in learning milieu where all of the other critical processes were favourable, levels of heuristic interaction, indicated by users interactions with cluster 1 and their subsequent system modifications, were woefully inadequate. There is an evident need to undertake further research to understand what the stimulants and barriers to heuristic interaction with the courseware by users are as there appear to be critical processes at work that are common to users rather than particular to any of the trial learning milieu. Identifying these critical processes is a significant hurdle in future courseware development. Further studies should be undertaken that seek to illuminate these user centred critical processes so that this new knowledge can guide the work of courseware developers.

In all trials and in all schools the profiles relating to users interactions with the cluster 1, and particularly in relation to the number of input devices that they considered, were the inverse of a profile that would indicate positive levels of heuristic interaction. There were five possible input devices to be considered, one of which was further sub-divided into two options. If a system user is approaching the courseware with a design agenda they will have an application context in mind. Once they understand the overall operating characteristics of the alarm system supported by the courseware there will be a number of options that have the potential to satisfy their individual needs. The possibilities in a typical range of project outcomes are most likely to reside in the mid regions of the availability scale, i.e. there is likely to be more than one method, applicable to the users working context, of triggering the alarm and it is unlikely that all five will be applicable. Hence, a peak should be evident in the profile somewhere in the mid regions of the scale. Whether this peak should be at 2, 3 or 4 in a scale with five possibilities is open to further study and debate, but it is reasonable to assume that this peak should tail off at both ends of the range of possibilities. An example of an expected curve is provided overleaf:

Expected Response to number of Inputs Viewed

However, as has been indicated, there were striking similarities between the profile

curves in all trials and in learning milieux where the critical processes were operating to

different effects. A typical profile is provided below:

Typical Response to No. of Inputs Viewed

Further research needs to be undertaken to establish how future practice should be informed by the opportunities for courseware development indicated by critical process 4. These opportunities present themselves in terms of the specificity of the application context indicated by the information that the courseware provides. However, further studies could also seek to answer supplementary questions that might stimulate the emergence of enhanced or additional critical processes. These supplementary questions might include:

• Are there specific and identifiable groups populating the slopes of the existing curves?

If so what shared characteristics typifies these populations: is there a gender split in the populations whereby there is a predominance of boys on the left hand slope and a predominance of girls on the right hand slope; are there groups of users with specific learning styles in the slope dwelling populations; are there factors associated with the way that information is presented, and the critical processes identified in this current research that affect these resident populations differently?

• Who are the small population who occupy the desirable location in the valley and do they have shared characteristics?

If so then this group may be the key to understanding the processes that stimulate the desired level of heuristic interaction with the courseware. However, this may be something of a blind alley as they represent a small minority of the global population. They may have characteristics that are congruent with the present courseware, but who become disenfranchised by future developments targeted at the masses.

• How can courseware be modified to invert the curve and stimulate a large population to reside on the peak?

It may be that the first two questions can provide the answer to the third, or that critical process 4 is all there is to understand and act upon. However, there may be further questions to ask, but these questions rely upon answers to those preceding them before they can be reasonably framed.

Bibliography

Apple Computer Inc. (1989) HyperCard Stack Design Guidelines - Addison-Wesley:Wokingham, England

Arents. H. and Bogaerts. W. (1991) Towards an Architecture for Third-Order Hypermedia Systems - Hypermedia - vol.3 no.2

Briggs. J. et.al. (1993) - Using Rules to Guide Learners Through Hypertext - Computers and Education:Pergamon Press:UK - vol.20 no.1

Brown. G. (1995) What is involved in Learning? - In **Desforges. C.** An Introduction to Teaching: Psychological Perspectives - Blackwell: Oxford

Cates. W. M. (1992) - Fifteen Principles for Designing More Effective Instructional Hypermedia/Multimedia Products - Educational Technology: December Edition

comp.sys.mac.hypercard - USENET newsgroup

Cornail-Engel. I. (1994) - The School Textbook - Can We Now Throw it Away? - Educational Media International - vol.31 no. 4

Coulouris. G. and Thimbleby. H. (1992) HyperProgramming: Building Interactive Programs with HyperCard - Addison-Wesley:Wokingham, England

Coupland. D. (1995) - Microserfs -Flamingo: London

DATA (1994) - Research Paper Number Two: A Survey of the Qualifications and Training Needs of Design and Technology Teachers in Secondary Schools - DATA:Wellesbourne

DES (1988) - National Curriculum Design and Technology Working Group: Interim Report - HMSO

DFE (1995) - Design and Technology in the National Curriculum - HMSO

Doherty. P. et.al. (1994) - In: **Banks. F.** Teaching Technology - Routledge: London

Duchastel. P. (1990) Examining Cognitive Processing in Hypermedia Usage - Hypermedia - vol. 2 no.3

Eggleston. J. (1992) - Teaching Design and Technology - Open University Press:Buckingham

Elliot. G.J., et al. (1995) Supporting the Paradigm Shift: Hypermedia Construction with Concept Maps - The Easy Way Forward - Innovations in Education and Training International - vol.34 no.4

Hendley. R. J. et.al. (1993) - Hypermedia Generation from Domain Representaions - Computers and Education:Pergamon Press:UK - vol.20 no.1

Hutchings. G. A. et.al. (1992) - Authoring and Evaluation of Hypermedia for Education - Computers and Education:Pergamon Press:UK - vol.18 no. 1

Jacobs. G. (1992) - Hypermedia and discovery based learning: a historical perspective - British Journal of Educational Technology - vol.23 no. 2

Kimbell. R. (1991) - The Assessment of Performance in Design and Technology: The Final Report of the APU Design and Technology Project 1985-1991 - Schools Examination and Assessment Council: HMSO

Kimbell. R. (1994a) - Tasks in Technology: An Analysis of Their Purposes and Effects - International Journal of Technology and Design Education - Kluwer Academic Publishers: Netherlands - no. 4

Kimbell. R. (1994b) - Understanding Technological Approaches: The Final Report of Research Activities and Results, ESRC

Kimbell. R., et. al. (1996) - Understanding Practice in Design and Technology - Open University Press: Buckingham

Knussen. C., et al. (1991) An Approach to the Evaluation of Hypermedia - Computers and Education:Pergamon Press:UK - vol.17 no.1

McKnight.C., et. al (1989) : In **Hutchings. G. A.** Et.al. (1992) - Authoring and Evaluation of Hypermedia for Education - Computers and Education:Pergamon Press:UK

Parlett. M. and Hamilton. D. (1972) Evaluation as Illumination: A New Approach to the Study of Innovatory Programs - Occasional Paper:Centre for Research in the Educational Sciences:University of Edinburgh

Patterson. J. (1994) - Teaching, Learning and Computers: A Bermuda Triangle? - The CTISS File No.17

Penfold. J. (1988) - Craft, Design and Technology: Past, Present and Future - Trentham Books: Stoke-on-Trent

Phillips. M. and Pugh. D. (1994) - How to get a Ph.D. : A handbook for students and their supervisors - Open University Press: Buckingham (Second Edition)

Phillips. W. A. (1990) - Individual Author Prototyping: Desktop Development of Courseware - Computers and Education:Pergamon Press:UK - vol.14 no. 1

Reushle. S. E. (1995) - Design considerations and features in the development of hypermedia courseware. - Distance Education - vol.16 no. 1

Robson. C. (1993) - Real World Research: A Resource for Social Scientists and Practitioner-researchers - Blackwell: Oxford

Salkind. N. J. (1991) - The Big Mac Book: second edition - Que: Carmel U.S.A.

Schulmeister. R. (1994) - A Shift Of Paradigm - Syllabus: European edition - no.4

Shepard. T. (1990) - Education by Design - Stanley Thornes: London

Siviter. D. & Brown. K. (1992) Hypercourseware - Computers and Education:Pergamon Press:UK - vol.18 no.1

Smeaton. A. F. (1991) - Using Hypertext for Computer Based Learning - Computers and Education:Pergamon Press:UK - vol.17 no.3

Smith. J. S. (1994a) - The use of IT in the Teaching and Learning of Design and Tecnology in Schools - Design and Technology Teaching - DATA: UK vol.26 no.3

Smith. J. S. (1994b) - Information Technology and Electronics - Electronics Education: IEE: UK - Autumn Edition

Stanton. N. A. (1994) Explorations into Hypertext: Spatial Metaphor Considered Harmful - Educational and Training Technology International - vol.31 no.4

Thimbleby (1995a) - WWW Paper: Introduction - http://www.cs.mdx.ac.uk/esrc/Author2.html

Thimbleby (1995b) - WWW Paper: Readers Problems - http://www.cs.mdx.ac.uk/esrc/Author2.html

Tizard. J. & Martin. J. (1992) - Using Electronics to design a controlled environment - paper presented at 1992 IDATER Conference.

Viau. R. & Larivée. J. (1993) - Learning Tools with Hypertext: An Experiment.- Computers and Education:Pergamon Press:UK - vol.20 no.1

Voogt. J. (1990) Courseware Evaluation by Teachers: An Implementation Perspective - Computers and Education:Pergamon Press:UK - vol.14 no. 4

Woodhead. N. (1990) - Hypertext and Hypermedia: Theory and Applications - Dotesios Printers: Wiltshire

Appendix 1: Trial Information

Teachers Notes

Introduction

Thank you for agreeing to take part in this, the first major trial of the software. It has been extensively user tested and piloted in one school prior to you receiving it. It is fully operational, stable and effective in its purpose as long as a few considerations are taken into account

The software gives pupils information so that they can design and make a simple security alarm system. The circuit is based around a 106D Thyristor. There are a choice of 6 inputs and 3 outputs giving the potential for 18 different systems. This is a very common circuit and should be familiar to most teachers participating in the trial. The actual extent of the project is left almost entirely with the teacher. The trial only asks for the pupils to complete the design and manufacture of the electronics. Some participants in the trial may wish to continue with the project and allow pupils to manufacture case parts and complete a full product design exercise.
N.B. The software only gives information regarding the design and manufacture of the electronics.

The software is 'intelligent'. In simple terms this means that it recognises who is using it, will know what they have already done and, hence, what they have left to do. This enables the software to give access to context sensitive information. The information available will, therefore, be different for different users. The integrity of the decisions that the software takes is dependent upon correct observance of the log on and log off procedures.

Pupils using the software must log on using their first and last name. They must always use the same name for each of their subsequent visits to the computer. If you are using more than one computer then pupils must continue to use the machine that they first logged on to. A new computer will treat them as a new user.

Visits to computers **must** be completed. The user knows that a visit is completed as they will see a 'Log Off' button flashing in the top left of the screen. The length of visits will vary according to various factors. In most circumstances an average length of visit is 5 minutes. The number of visits that any individual will make again depends upon various factors. A minimum of 5 visits must be made to gain enough information to complete the manufacture of the circuit.

Certain screens have a 'Print' button. Pupils should be encouraged to print the information from screens that have the print button as this is essential information for them to complete the manufacture of the circuit.

The log on and log off procedures are illustrated in the notes and OHPs provided.

Before making their first visit to the computer pupils will need to be introduced to the project and understand the basic concept of the security alarm system. The systems available are relatively simplistic but are appropriate for the level at which the project is set (Yr9 KS3). The pupils will need to have decided upon a context in which their system will be used and have drawn up some basic performance criteria.

e.g. The pupil decides to design and make an alarm system to protect their bicycle. They decide that the alarm system should make a noise if someone moves the bike.

The actual amount and nature of work that is done by the pupils before their first visit to the computer will vary according to your own delivery methods and department policies. They must, however, have at least the above if they are going to meaningfully engage with the software.

Project Structure

As already described the nature of the work that you do with pupils away from the computer is up to you. It is worth, however, considering the following basic structure if the two are to fit together in a meaningful way:

1. Project introduction

Pupils to decide upon a context for the alarm to be used in and some basic performance criteria.

2. Introduction to the software.

Pupils are shown how to log on, print and log off. This can be done using the computer or the OHPs provided.

3. First visit to computer.

Pupils make their first visit to the computer after they have completed item 1 to your satisfaction.

4. PCB Manufacture.

The first visit to the computer allows pupils to design their system and culminates by giving them a PCB layout. They must complete the manufacture of the PCB before they can continue with the construction of the alarm system.

N.B. Although there are potentially 18 different alarm systems they can all be made using the same PCB. This overcomes any problems with pupils changing their decisions as a result of further consideration and engagement with the software.

5. Completion of the circuit.

Subsequent visits to the computer will give pupils the information that they need to complete the manufacture of the circuit. They should get a printout telling them how to manufacture the input, process, output, to connect a battery and switch and how to set up and test their circuit. These areas are covered in the next four visits. Some pupils may need to make more than four visits if they change decisions about what devices to use.

6. Fault Diagnosis.

If a pupil has got as far as completing the set up and testing procedure and the system does not work then the next time they log on to the software they will be given a fault finding option. This option is available on all subsequent visits.

7. Design and manufacture of case parts (optional).

Operating the software

Before the start of each lesson make sure that all computers to be used are switched on, connected to a working printer and have the software loaded.

When you load the software you will be prompted to enter a password. This is to prevent curious people not involved in the trial from using the software and corrupting the data that it collects.

The password is: **applepower**

If the password is entered incorrectly then the user will be warned and the software will automatically quit.

At the end of the lesson you need to quit the software to prevent access by users not involved in the trial. To quit the software:

1. Click the log on button

2. Type in **hyperteacher** as the log on name.

This will take you to a special teacher's page. One of the options on this page is to quit.

N.B. You should never let anybody else have access to these passwords or the teachers page.

The Teacher's Page

The '**Quit**' button quits the software.
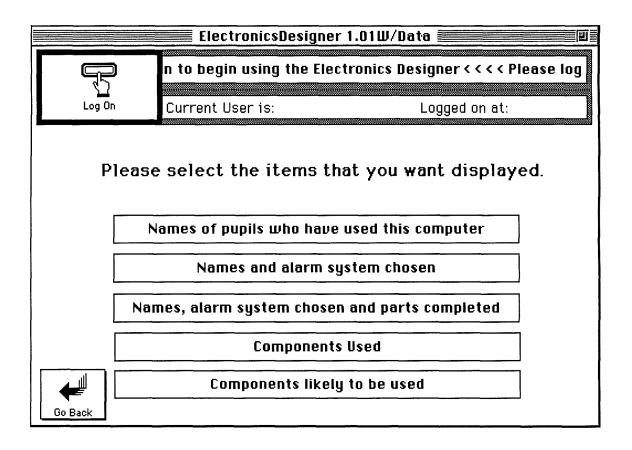
The '**Return for use**' button takes the software back to the first screen ready for pupils to use it.

The '**Print test**' button will print this screen to the connected printer. Use this to check if the printer is working correctly. You may wish to do this before the start of a lesson.

The '**Reset a visit**' button allows you to erase part of the computers stored data. This may be necessary if something has gone wrong during a pupils visit or if they cannot get access to earlier information. Pupils are allowed access to all information until they have completed the circuit. On all visits after this they are presented with a screen that contains the fault finding option. To allow access to this earlier information you will have to erase their latter visits. Simply press the button and follow the instructions.
N.B. Only use this facility as a last resort and with extreme caution!

The '**Progress Report**' button allows you to find out various things. If you click on it you will see the following screen.

```
═══════════════ ElectronicsDesigner 1.01W/Data ═══════════════  ▣
┌─────────────┬──────────────────────────────────────────────────┐
│    ▭         │ n to begin using the Electronics Designer < < < Please log │
│   ╔═╗        ├──────────────────────────────────────────────────┤
│   Log On     │ Current User is:                    Logged on at:  │
└─────────────┴──────────────────────────────────────────────────┘

           Please select the items that you want displayed.

          ┌──────────────────────────────────────────────┐
          │   Names of pupils who have used this computer  │
          └──────────────────────────────────────────────┘
          ┌──────────────────────────────────────────────┐
          │          Names and alarm system chosen         │
          └──────────────────────────────────────────────┘
          ┌──────────────────────────────────────────────┐
          │  Names, alarm system chosen and parts completed │
          └──────────────────────────────────────────────┘
          ┌──────────────────────────────────────────────┐
          │                 Components Used                │
┌──────┐  └──────────────────────────────────────────────┘
│  ◀═  │  ┌──────────────────────────────────────────────┐
│Go Back│  │            Components likely to be used        │
└──────┘  └──────────────────────────────────────────────┘
```

There are 5 formats/types of data that you can display. Simply click on the button that describes the data that you require.

The '**Go Back**' button will take you back to the Teacher's Page.

For any further enquiries you can contact me at the University during working hours on:
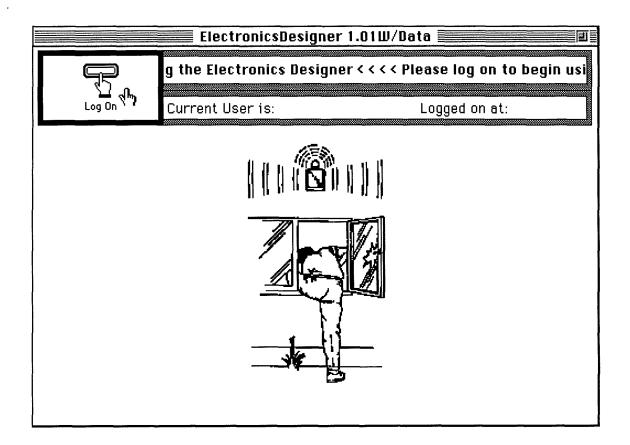
Tel - XXXX XXX XXXX
Fax - XXXX XXX XXXX
email - X.XXXXXXX@XXX.XX.XX

Outside working hours on:

Tel - XXXX XXX XXXX

Thank you once again for taking part in the trial and for taking the trouble to read these notes.

The following sheets/ohps show the screens used to **log on** and **log off**. Each sheet has listed points to make pupils aware of. (You may of course expand on this as you see fit)

1. All users must log on to the program before they can use it. This is so that the program can 'get to know them'. They must log on as the**same person** each time, otherwise the computer will give them the wrong information.

N.B. If you have more than one computer running the program then the user must use the same computer each time. If they don't then the machine won't recognise them and will give them the wrong information.

2. To log on click on the log on button at the top left of the screen.

Goto sheet 2 »

```
┌─────────────────────────────────────────────────────────────┐
│              ElectronicsDesigner 1.01W/Data                   │
├──────────────┬────────────────────────────────────────────────┤
│   ┌─────┐    │ nics Designer < < < Please log on to begin using the Electr │
│   │ 🖰  │    ├────────────────────────────────────────────────┤
│   └─────┘    │ Current User is:              Logged on at:      │
│   Log On     │                                                  │
└──────────────┴────────────────────────────────────────────────┘
```

3. The user then has to type in their name. This must be their first name followed by their last name; the computer will not accept anything else.

Note to teacher: The program recognises the user by their name. If in the **very unlikely** event of you having two pupils who will use the computer that have **exactly** the same forename **and** surname then some action will need to be taken.

Suggest -

i. If you have more than one computer that is running the program then get the two users to use different machines.

ii. Change one of the names, e.g. by getting them to append a number at the start (1John Smith) .

4. When the user has typed in their name then click on the 'OK' button.

ElectronicsDesigner 1.01W/Data

nics Designer < < < < Please log on to begin using the Electr

Log On

Current User is: Logged on at:

Logging On
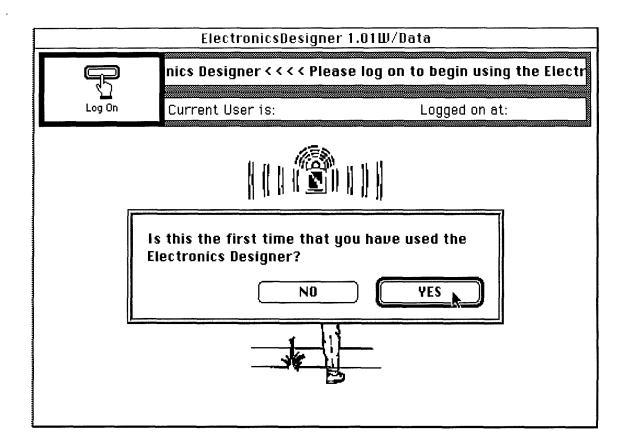
Please check the spelling
of your name – Sally Smith

Is it correct?

NO   YES

5. The computer will then ask the user to check the spelling of their name. This is very important. As far as the computer is concerned, an incorrectly spelled name is a different person!

6. If the spelling is incorrect then the user can click on 'NO', this will give them a chance to type in their name again.

7. If the spelling is correct then click on 'YES'

Goto sheet 4 »

8. This is the first time that they will have used the machin
so the computer will not recognise them. It will ask if this i
the first time that they have used the program.
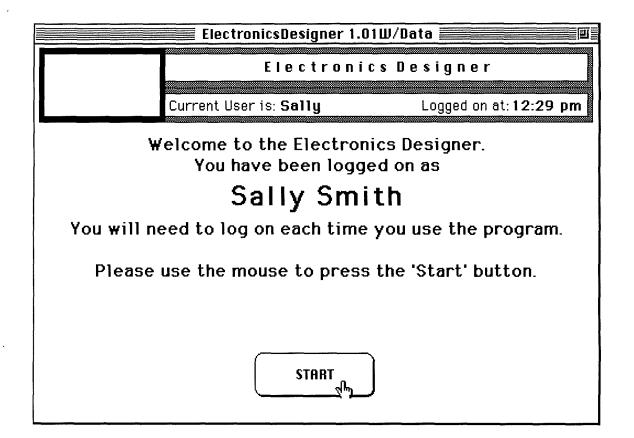
9. Clicking on 'NO' will give them a chance to reenter their
name or to stop the log on procedure.

N.B. This is important in later visits. If the computer does not recognise them on their
subsequent visits then something is wrong. The most common problem is that they
have either not entered their name correctly or that they are using a different
computer.

10. On this first visit click on 'YES'.

```
┌─────────────────────────────────────────────────────────────┐
│ ≡≡≡≡≡≡≡≡≡≡≡≡≡≡≡≡ ElectronicsDesigner 1.01W/Data ≡≡≡≡≡≡≡≡≡ ▣  │
│ ┌───────────┬─────────────────────────────────────────────┐ │
│ │           │         Electronics Designer                │ │
│ │           ├─────────────────────────────────────────────┤ │
│ │           │ Current User is: Sally      Logged on at:12:29 pm │
│ └───────────┴─────────────────────────────────────────────┘ │
│                                                               │
│              Welcome to the Electronics Designer.             │
│                 You have been logged on as                    │
│                                                               │
│                    Sally Smith                                │
│                                                               │
│       You will need to log on each time you use the program.  │
│                                                               │
│                                                               │
│         Please use the mouse to press the 'Start' button.     │
│                                                               │
│                                                               │
│                                                               │
│                      ┌──────────────┐                         │
│                      │   STRRT       │                         │
│                      │          ↖    │                         │
│                      └──────────────┘                         │
│                                                               │
└─────────────────────────────────────────────────────────────┘
```
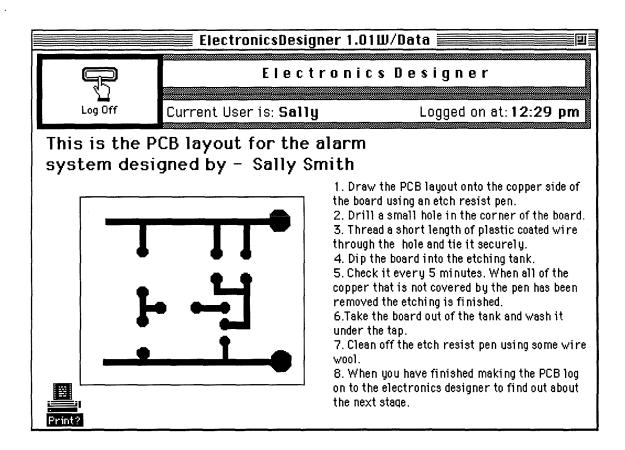
11. The log on procedure is now complete. The computer tells the user who they have been logged o as.

Note to teacher: The bar at the top of the screen now shows the first name of the user and the time that they logged on. This is meant to give you a quick reference to see that the correct person is using the machine. If **Sally** is not using the machine then something is amiss.

12. Click on the 'Start' button to begin using the program.

ElectronicsDesigner 1.01W/Data

Electronics Designer

Log Off

Current User is: **Sally**   Logged on at: **12:29 pm**

This is the PCB layout for the alarm system designed by - Sally Smith

1. Draw the PCB layout onto the copper side of the board using an etch resist pen.
2. Drill a small hole in the corner of the board.
3. Thread a short length of plastic coated wire through the hole and tie it securely.
4. Dip the board into the etching tank.
5. Check it every 5 minutes. When all of the copper that is not covered by the pen has been removed the etching is finished.
6.Take the board out of the tank and wash it under the tap.
7. Clean off the etch resist pen using some wire wool.
8. When you have finished making the PCB log on to the electronics designer to find out about the next stage.

Print?

13. This is the final screen for the first visit. It shows the PCB layout for the alarm system that they have designed.

14. Note the 'Print' button. (This will be flashing). If user see a flashing print button on any screen then they should click on it to print the information.

15. Note the 'Log Off' button. (This will be flashing). If users see a flashing log off button then they know that they are at the end of a visit. Check to see if they shoulc print the information that is on the screen. Click on the 'Log off' button to finish using the program.

N.B. It is **very** important that visits are **completed** and that the user **logs off**. This will ensure that all users get the information that relates to them and that the program will continue to function correctly.

Appendix 2.1: End of Trial Interview Schedules

Interview Questions - Trail 1

1. Have you taught electronics before to this age group?

Prompt - what projects have you done?

2. Have you taught electronics to any other age group?

Prompt - what projects have you done?

3. Do you feel that these projects have enabled pupils to :
    Design a circuit
    Select components
    Take decisions about the electronics

4. How would you rate your own confidence and ability to teach electronics as part of design and technology at this level?

5. What are your perceptions of how your class responded to using this software?
Prompts:
    Motivation
    Work rate
    Engaging in the project
    Success rate
    Empowering or confusing
    Computer numbers

6. What are your feelings about the use of this software?
Prompts:
    Less or more control over the teaching situation
    Constrictive or supportive
    Sequencing of content
    Level of language used
    Changes in pedagogy
    Empowering or confusing
    More or less time to support pupils in their work.

7. Did you use the facility to monitor pupils progress with the program?

Prompt - Was this useful information or would other information be useful?

8. If available would you like to continue using this software with further groups?

9. What changes would you like to see in the content or structure of the software?

10. If available would you use software of this type in other design and technology projects?

11. Have you used any other educational software?

Prompt - what are your opinions of it ?
        - Are you still using it?

12. Is there any educational software available that you would like to use?

Prompt - Why would you like to use it ?

Do you have any further comments?

Interview Questions - Trial 2

1. In considering the software, what sort of task is it best used to support:

A contextual task which is very open and leaves most of the design decisions to the pupils.

A framed Task which has some constraints but leaves the significant design decisions to the pupils.

A specific Task which is tightly defined.

Please explain your choice.

2. The current National Curriculum divides design and technological activity into three main categories. Which of these categories have you directed most of your teaching towards when teaching this project:

To investigate, disassemble and evaluate products and applications.

A focused practical task in which pupils develop and practice particular skills and knowledge

A design and make assignment in which pupils design and make products.

Could you explain your reasons for this?

3. In considering the national curriculum programmes of study for key stage 3, how well has the software performed in:

allowing pupils to develop their capability in designing and making products.

in providing teaching and learning opportunities for yourself and your pupils.

in fulfilling the specific requirements of the programme of study.

4. Consider that design and technology capability might be defined in terms of how autonomous pupils are in the successful derivation and completion of tasks and that a successful teaching strategy might be a process whereby pupils are gradually 'weaned' into this mode of working.

How much do you agree with this statement?

How important do you feel pupil autonomy is in design and technology projects?

How successful has the software been in allowing you to pass control of the project to your pupils and allowed them to act with an appropriate level of autonomy?

5. If the software had not been available, what problems do you feel you might have encountered in delivering this project with similar levels of pupil autonomy?

Have these problems been borne out by your own previous experience?

6. In considering your answer to the last question, has the nature of the problems which you, or your pupils, experienced changed.

7. Can you think of other contexts in which similar types of software might be valuable?

8. Do you have any further comments?

Appendix 2.2: dataExtract Screen Shots

⛾ File Edit Go Tools Objects Font Style

dataExtract

Andy Bardill	User	System Chosen	**Correct**
Avron Grant	tim trimble	31 WindowDoor Switch/Piezo	**Incorrect**
Bill Bloggs			

```
Andy Bardill          User                          System Chosen                 ⌂    ┌──────────┐
Avron Grant           tim trimble                   31 WindowDoor Switch/Piezo          │ Correct  │
Bill Bloggs                                                                             │ Incorrect│
Charlie Clegg         Number of Visits                                                  └──────────┘
Dave Deckchair        6                                                            ⌄    ┌──────────┐
Eric Eccles                                                                             │ pathBugger│
Fred Finlay           Visit Durations            ⌂   Design                    ⌂   Notes:         ⌂
George Gregg          1 -- 3  mins -- Design 31       Question 1
Harry Hart            2 -- 2  mins -- Input 31        incorrect - 4
Ian Ingles            3 -- 1  mins -- Process 31      correct - 3
john doe              4 -- 1  mins -- Output 31
John Junior           5 -- 1  mins -- Battery         Question 2
john smith            6 -- 3  mins -- Fault On        input correct
John Smyth                                            output incorrect
larry lamb            Total Use Time 11 Minutes       output correct
Sally Smith                                           process correct
tim trimble
zeta zero          ⌄                               ⌄                            ⌄                  ⌄
```

Calculate Group Results	Users,Visits+times to Sheet	Times Between to Sheet	UUT + TBU to Sheet
Graph This User's Visits			
Graph This users Results			
Graph Systems Built			
Graph Total Use Times			

```
Users,Visits+times to Sheet        Times Between to Sheet       UUT + TBU to Sheet
Pupil 1   5    Design   5   33 ⌂   Pupil 1  NS    CV    SS ⌂    Pupil 1   5     Design ⌂
  Input  3  33   Process  3        NS                             5  33   NS
  33  Output  3   33          ⌄   Pupil 2  NS    NS    SS ⌄    Input  3  33   CV
Design  8   22   Input   3     ⌂   12:58  13:59  61  NS  ⌂     Process  3   33
22  Output   3   22            ⌄   14:02  14:03   1  CV  ⌄     SS  Output  3        ⌄
```

| Maximise Logord | Log in Order | Pupil 1 Window/Door | Alpha by Surname |
| Minimise Logord | Anon in Log Order | | Design Visit |

```
                                                              P⌂ P⌂ P⌂
                                                              up⌄ up⌄ up⌄
```

| Andy Bardill question 1 | Andy Bardill question 2 | Andy Bardill question 3 | Andy Bardill question 4 |
| correct - 3 | micro incorrect | thuristor correct | bulb correct |

```
Andy Bardill question 1 ⌂  Andy Bardill question 2 ⌂  Andy Bardill question 3 ⌂  Andy Bardill question 4 ⌂
correct - 3             ⌄  micro incorrect         ⌄  thuristor correct       ⌄  bulb correct           ⌄
                           Andy Bardill 10:28 am 27/8/96 ⌂   Andy Bardill 10:28 am 27/8/96 ⌂
Bill Bloggs 27/8/96   22   logged off at 10:32 am 11   ⌄   Bill Bloggs 10:33 am 27/8/96   ⌄
```

The dataExtract software designed and written for this research project gives three primary functions:

• import user model data from used courseware;

• rapidly 'sift' through the data, and construct basic profiles, to begin to identify significant features from a trial; and

• prepare this user model data for export as tab delimited text for detailed analysis in a spreadsheet programme.

Raw data is imported into the collapsed base fields from the used courseware.

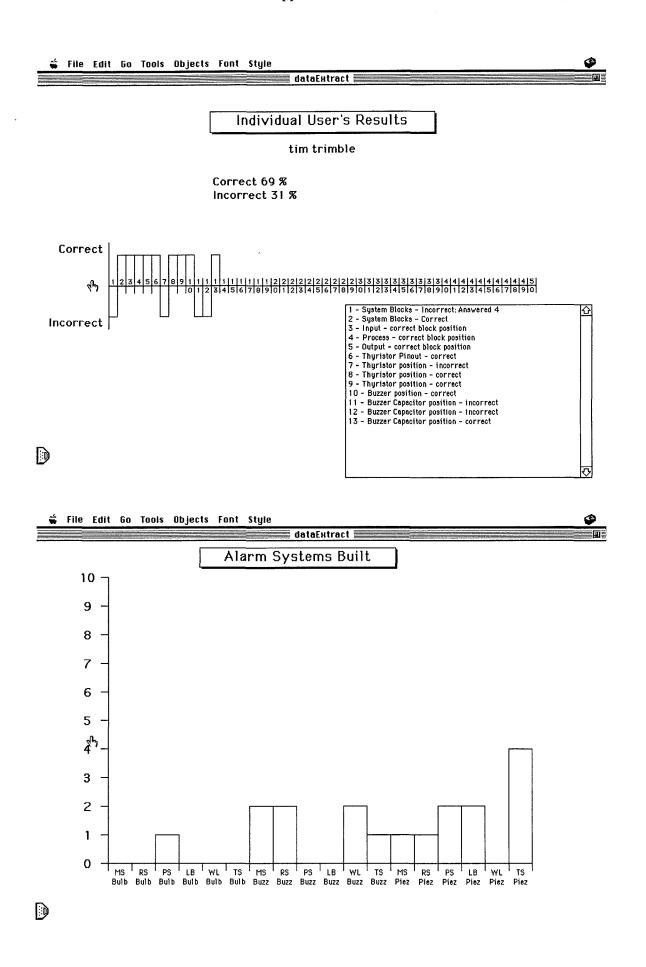The import script also sorts this data into a name list ready for 'sifting'

File   Edit   Go   Tools   Objects   Font   Style

dataExtract

Andy Bardill	User	System Chosen	Correct
Avron Grant	tim trimble	31 WindowDoor Switch/Piezo	Incorrect
Bill Bloggs			
Charlie Clegg	Number of Visits		
Dave Deckchair	6		pathBugger
Eric Eccles			
Fred Finlay	Visit Durations	Design	Notes:
George Gregg	1 -- 3 mins -- Design 31	Question 1	
Harry Hart	2 -- 2 mins -- Input 31	incorrect - 4	
Ian Ingles	3 -- 1 mins -- Process 31	correct - 3	
john dde	4 -- 1 mins -- Output 31		
John Junior	5 -- 1 mins -- Battery	Question 2	
john smith	6 -- 3 mins -- Fault On	input correct	
John Smyth		output incorrect	
larry lamb	Total Use Time 11 Minutes	output correct	
Sally Smith		process correct	
tim trimbl			
zeta ze..o			

Calculate Group Results	Users,Visits+times to Sheet	Times Between to Sheet	UUT + TBU to Sheet
Graph This User's Visits	Pupil 1 5 Design 5 33	Pupil 1 NS CV SS	Pupil 1 5 Design
Graph This users Results	Input 3 33 Process 3	NS	5 33 NS
Graph Systems Built	33 Output 3 33	Pupil 2 NS NS SS	Input 3 33 CV
Graph Total Use Times	Design 8 22 Input 3	12:58 13:59 61 NS	Process 3 33
	22 Output 3 22	14:02 14:03 1 CV	SS Output 3

| Maximise Logord | Log in Order | Pupil 1 Window/Door | Alpha by Surname | P up P up P up |
| Minimise Logord | Anon in Log Order | | Design Visit | |

Andy Bardill question 1	Andy Bardill question 2	Andy Bardill question 3	Andy Bardill question 4
orrect - 3	micro incorrect	thuristor correct	bulb correct
Bill Bloggs 27/8/96 22	Andy Bardill 10:28 am 27/8/96	Andy Bardill 10:28 am 27/8/96	
	logged off at 10:32 am 11	Bill Bloggs 10:33 am 27/8/96	

● Clicking on any name in the name list unpacks and presents the individual visits showing: the visit number; the visit duration to the nearest minute; the activity undertaken during the visit and a two digit code indicating the alarm systems that is being investigated.

● The Systems Chosen field show all alarm system combinations that this user has chosen. More than one system indicates a change in chosen system after the design visit has taken place.

● Clicking on a visit in the Visit Duration field shows the results of the subsequent orientation activity on the user's next visit to the courseware.

● Clicking on these functions constructs a rapid overview profile from the courseware user model data. These profiles are shown on the next two pages.

File   Edit   Go   Tools   Objects   Font   Style

dataExtract

Individual User's Results

tim trimble

Correct 69 %
Incorrect 31 %


```
1 - System Blocks - Incorrect: Answered 4
2 - System Blocks - Correct
3 - Input - correct block position
4 - Process - correct block position
5 - Output - correct block position
6 - Thyristor Pinout - correct
7 - Thyristor position - incorrect
8 - Thyristor position - correct
9 - Thyristor position - correct
10 - Buzzer position - correct
11 - Buzzer Capacitor position - incorrect
12 - Buzzer Capacitor position - incorrect
13 - Buzzer Capacitor position - correct
```

File   Edit   Go   Tools   Objects   Font   Style

dataExtract

Alarm Systems Built

 File   Edit   Go   Tools   Objects   Font   Style

dataExtract

Individual User Visits: tim trimble

T
i
m
e

(Mins.)

10
9
8
7
6
5
4
3
2
1
0

Design   Input   Proc.   Output   Batt.   FF-On

 File   Edit   Go   Tools   Objects   Font   Style

dataExtract

Total Group Use Times

O
c
c
u
r
r
e
n
c
e
s

20

15

10

5

0

0   5   10   15   20   25   30   35   40   45   50   55   60

Time (Mins.)

File Edit Go Tools Objects Font Style

dataExtract

Andy Bardill	User	System Chosen	Correct
Avron Grant	tim trimble	31 WindowDoor Switch/Piezo	Incorrect
Bill Bloggs			
Charlie Clegg	Number of Visits		pathBugger
Dave Deckchair	6		
Eric Eccles			
Fred Finlay	Visit Durations	Design	Notes:
George Gregg	1 -- 3 mins -- Design 31	Question 1	
Harry Hart	2 -- 2 mins -- Input 31	incorrect - 4	
Ian Ingles	3 -- 1 mins -- Process 31	correct - 3	
john doe	4 -- 1 mins -- Output 31		
John Junior	5 -- 1 mins -- Battery	Question 2	
john smith	6 -- 3 mins -- Fault On	input correct	
John Smyth		output incorrect	
larry lamb	Total Use Time 11 Minutes	output correct	
Sally Smith		process correct	
tim trimble			
zeta zero			

Calculate Group Results	Users,Visits+times to Sheet	Times Between to Sheet	UUT + TBU to Sheet
Graph This User's Visits	Pupil 1 5 Design 5 33	Pupil 1 NS CV SS	Pupil 1 5 Design
Graph This users Results	Input 3 33	Process 3	NS	5 33 NS
Graph Systems Built	33 Output 3 33	Pupil 2 NS NS SS	Input 3 33 CV
Graph Total Use Times			Process 3 33
	Design 8 22 Input 3	12:58 13:59 61 NS	SS Output 3
	22 Output 3 22	14:02 14:03 1 CV	

| Maximise Logord | Log in Order | Pupil 1 | Alpha by Surname | P | P | P |
| Minimise Logord | Anon in Log Order | Window/ Door | Design Visit | up | up | up |

Andy Bardill question 1	Andy Bardill question 2	Andy Bardill question 3	Andy Bardill question 4
rrect - 3	micro incorrect	thuristor correct	bulb correct
	Andy Bardill 10:28 am 27/8/96	Andy Bardill 10:28 am 27/8/96	
Bill Bloggs 27/8/96 22	logged off at 10:32 am 11	Bill Bloggs 10:33 am 27/8/96	

The user model data can be prepared for output as tab delimited text in three forms: User number (to anonymise the data), visit type and time; the times between the visits standardised into SS-same session, NS-new session and CV-concurrent visit classifications or; a combination of the first two forms. The resultant data sets can simply be copied and pasted into a spreadsheet programmes, e.g. MicroSoft Excel.

A fourth data set, relating to the number of input and output components investigated during the design visit, can be prepared as a tab delimited text file ready for cutting and pasting into a spreadsheet programme.

Appendix 3.1: Interview Transcripts - School A

End of Trail 1 Interview

School A, Teacher A

Question 1: Have you taught electronics before to this age group?

Response: Yes

Probe: What sort of projects have you done with them?

Response: Simple sort of logic...mostly...just with one gate or two gates, an output in the circuit and an input...

Probe: ...what sort of product?

Response: More of a system than a product. So you take a design problem and you try to produce a system for it. You're not actually producing a product. So you'd actually just package it using, you know, a bought in box or something like that.

Question 2: You've taught electronics to other age groups as well?

Response: Yes.

Probe: So what sort of projects have you done there ? There's a broad spectrum I...

Response: Well, there's 'A' level...They'd be individual projects...I mean I've taught to GCSE electronics and microelectronics but the actual practical electronics I suppose mostly would be project work. So it would be very varied... 'A' Levels do projects as well.

Question 3: So concentrating on this age group, of year 9 kids and the projects that you have done before, do you feel that those projects have enabled them to either design a circuit, or maybe select components to go in the circuit, or to take any decisions about the electronic components that they use?

Response: With previous projects it's very difficult...I suppose it would depend on the pupil but usually they forget a lot after they've done it ... like a lot of things because they don't get backup... constant backup...they tend to forget it.

Probe: So is the project set up, the ones you've done before, so that they have a circuit that they have to build?

Response: Yes, very similar...most of the chips will have gates in the same positions so the circuits are going to be very similar.

Probe: Do they take decisions about selecting components?

Response: Yes, yes they would...I mean...It would be... to a certain extent yes, but you would channel your sort of project so that you don't have too many...so that they don't have to make too many decisions and it's going to be obvious.

Question 4: So just generally, How do you rate your own confidence and ability to teach electronics, within design and technology, at this level?

Response: At this level, yes I feel confident.

Question 5: What are your perceptions of how your class responded to using the software?

Response: Initially they responded very well. They were very keen on the actual software and they wanted to go through it.

They were limited though...I think with the number of machines that we had. And I think that because of that, you know, one or two of them were put off because they took a long time to get on to one of the machines. But once they were on there it was fine.

They were motivated and they got their printouts and they were away.

Probe: So how do you feel about the work rate? What were your perceptions of how they were responding? Was their work rate better than normal or worse than normal ?

Response: It's difficult to judge because I...this particular group I haven't taught before, but they responded very well, I don't think there was any of them who didn't respond well to what they were doing.

Probe: What about how they engaged in the project? Were they fully engaged in the project or were they kind of drifting off to other things, comparing it to your normal kind of experience?

Response: No, they were fully engaged, but the problem was that when one computer did fail...that was a problem because they tended then to just copy what other people were doing because they were lagging behind, they would copy and I think that had a knock on effect.

Probe: So they were motivated towards the project but couldn't necessarily access the software.

Response: Yes and in the end because they couldn't access it, or they'd had problems accessing it, they would then bypass it .

Probe: What about the success rate at the end of the project?

Response: Well, on the whole they were working but we had the problem with the thyristors as well, which...you know as they were coming up they weren't actually working at all. We couldn't work out why they weren't working, but it just turned out that the thyristors just weren't right.

Probe: In general do you think that, by using this software, the pupils found it to be an empowering situation or did they find it to be a confusing situation?

Response: No, they weren't confused by it. I think they thought that it was...they were quite impressed by it I think. The whole idea.

Question 6: What are your feelings about the use of this software?

Response: I think it's a very good media. I think we could be able...but we would need to have more computers actually in operation. I don't think one...the way that I would teach it anyway, I don't think one computer is enough. I think we should have had about five in there and that would have sufficed. We would have been ok, so long as they all had printers attached to them.

Probe: In general do you feel that it gave you less or more control over the teaching situation?

Response: I think there was more control. Whether that was...I think I would want to do it

with a number of groups before you can make a sort of value judgment, but the group was very good, they were keen and got on with it. So it...you know ...whether that was because of the software or because of the group I don't know.

Probe: Would you say that using the software was a constrictive thing or a supportive thing?

Response: Yes supportive.

Probe: How do you feel about the sequencing of the content in the software, compared to how you would normally teach, and the level of the language that was used?

Response: I think the software actually made sure that you sort of compounded, over and over again, certain things that they would perhaps forget and you would just think that they understood and...you know...like they were tested and like the three stages, they were constantly reminded about it. So I think that helped a lot.

Probe: Did it change your pedagogy at all; did it change the way that you taught the class?

Response: No not really apart...yes...I mean it does because they're actually operating a computer, but I think that it changes it a little bit, but I was just working with another medium. I wasn't aware that I was teaching differently.

Probe: When using the software with the group did you find it an empowering or confusing situation?

Response: It wasn't confusing at all...It wasn't particularly empowering either.

Probe: Did you find that it gave you more or less time to support the pupils in actually doing their work?

Response: Initially, more time, but when things started going wrong, like printers wouldn't work, or that computer went...then it began to be a bit of a struggle, but if everything runs smoothly it gives you a lot more time to sit down with those who are struggling.

Question 7: Did you use the facility to monitor the pupils progress at all?

Response: In what way?

Probe: You know when you can log on as 'Hyperteacher' and that allows you to see what people have been doing. Did you use that facility at all?

Response: Yes, I did, yes.

Probe: Was the information that was given useful?

Response: Well only that they all did the same, yes.

Yes I mean it was quite useful.

Probe: Would you have like to have seen any other information; was there other information that you wanted to get?

Response: I don't think so, I mean it gave all of the information that you needed really. It gave the components that you would probably need. It gave the stage...how many times they had logged on and whatever, so it gave sort of quite adequate information.

Question 8: If it was available would you like to continue using the software with further groups?

Response: Yes, yes I would.

Question 9: Would you like to see any changes in the content or structure of the software?

Response: No I don't think so...I mean sometimes it went through the stages...or, or it was slow in certain stages. That might be because of the actual computers themselves.

Probe: So you would like to see it speeded up?

Response: Yes a little bit.

Question 10: If available would you use this particular type of software in other design and technology projects?

Response: Yes it could be. I haven't really thought about where you could use it, but you could use it.

Question 11: Have you used any other educational software?

Response: Well I tried. I tried 'Crocodiles' but...

Probe: Crocodile Clips?

Response: Yes

Probe: So what were your opinions of it?

Response:I didn't think it was very good...I just thought that...well every time I started...I did a circuit that I was pretty sure that was going to work alright and it just exploded it, so I was...but I wasn't that impressed by it. I didn't think it was very user friendly.

Probe: Are you still using it?

Response: No

Probe: Did you use that with children at all?

Response: We only had that as a demonstration.

Probe: Have you used any other educational software at all?

Response: Only going back to sort of BBC stuff; pineapple I think it was.

Probe: I'm not just concentrating on electronics here I'm talking about the whole of design and technology.

Response: It depends on what sort of software you mean.

Probe: I'm talking really about educational software.

Response: Well, I mean we've used the sort of basic programs for Apple, but not...

Question 12: Is there any educational software available that you would like to use?

Response: Yes, I mean the...not in this particular area...you mean...

Probe: Generally across design and technology.

Response:I like to see more user friendly graphics programs, 3D modelling programs and that sort of thing. That would be a lot...a lot of help really.

Question 13: So that's really the interview finished. Do you have any further comments that you would like to make?

Response: No.

14 mins

End of trial 2 Interview

School A, Teacher A

Question 1: In considering the software what sort of task do you think it is best used to support; and there are three choices here. Either:

a contextual task which is very open and leaves most of the design decisions to the pupils;

a framed task which has some constraints but leaves the significant design decisions to the pupils;

or a very specific task which is tightly defined?

Response: I would say it was specific.

Probe: A very specific task; do you want to explain your choice?

Response: Because of the time constraints. I think that er...

Probe: So what time constraints did you have?

Response: A sort of circus within 6 weeks; making sure that you got the project finished within that time. So from our point of view that's what the best option was.

Probe: So when you say a specific task, how were you directing your pupils into doing a specific task when using the software?

Response: Well the... I suppose the specific task would be within just a basic package. Does that make sense? So, in other words...

Probe: What do you mean by package?

Response: We wouldn't have put the design element...if it had been a real sort of long design project then we'd have got them to design a packaging and, you know, for the context that it was in and sort of try to put more emphasis on that.

Probe: So what was the focus of the brief that you set then; was it to design and make a product or to design and make a circuit?

Response: No it was the electronics that we were concentrating far more on, you know, looking at what the stages of a circuit are and then making a circuit, because they have not had any experience of that before.

Question 2: The current national curriculum divides design and technology activity into three main categories. Which of these categories have you directed most of your teaching towards when teaching this project. Was it either:

to investigate, disassemble and evaluate products and applications;

a focussed practical task in which pupils develop and practice particular skills and knowledge;

or a design and make assignment in which pupils design and make products?

Response: The second one.

Probe: The second one which is the focussed practical task.

Response: Yes very.

Probe: So you've already, in question 1, explained some of the reasons for that. Would you like to expand on that?

Response: Well in the...throughout the year they'll be trying to expand through design in different projects, but we want to make sure that they have all...all looked at an electronic circuit in the three stages and to make sure that they have all constructed something, **but of interest to them**, which they found the software interesting and were able to get a product out of it quite quickly.

Probe: So your delivery model in year 9 is a focussed kind of skills delivery?

Response: Very much yes, yes...in certain areas, but there are modules which are design, you know, and not so focussed.

Probe: So are those modules in things that they have had experience of before then, for example in construction materials?

Response: Yes, so we try to aim a focussed task early on and then they'd have a chance to expand on that...

Probe: Into some kind of framed task?

Response: ...a capability task, yes.

Probe: So by year 9 they've not done any electronics before?

Response: They've not, no.

Question 3 (i) : In considering the national curriculum programmes of study for Key Stage 3, how well has the software performed in allowing pupils to develop their capability in designing and making products?

Response: I think the software package itself would have been ok in developing the product. The only problem that we had was that we didn't have enough...enough computers really for them to...you know, because they all wanted to use the computers at the same time really and we had problems with the printers as well. But if we had had more computers, perhaps 7 on the go for a full class set, then it would have made life a lot easier and it would have been self motivating...

Probe: ...and perhaps because you've got a 6 week time frame, and it's a focussed practical task, then perhaps its...

Response: Yes, if it was a longer period then you could get them to, groups of them to do different design paths so it would be far better from that point of view with fewer computers.

Question 3 (ii): And so the same question again; how well do you feel its performed in providing teaching and learning opportunities for yourself and your pupils?

Response: I think that the...apart from the problems that we had with computers crashing and printer problems, it was very good. I think the kids were able to use it well and learn from it as well. The only problem which I found that some of them were doing, because it was in a sort of 6 week module, that perhaps some of the faster pupils were getting...going to the computer, but because the kids weren't...all of them weren't able to get on to the computer at one stage, they would try and jump a stage by copying or looking at what the faster ones had

done.

Probe: So they were sharing information between themselves?

Response: They were sharing it, but perhaps not learning, but only looking at what the others had...you know, whereas the first few through would have looked at the components, gone through all of the sections. The others were tending to just look at what they had to do to the additions to it so there was no learning.

Probe: So they were just getting the essential information to make the product but perhaps weren't interacting with the resource to do the learning on the way?

Response: Yes.

Question 3 (iii): And how effective do you feel it has been in fulfilling the specific requirements of the programme of study?

Response: Yes...I mean there aren't really specific requirements in the programmes of study because they are very sort of...

Probe: Bland?

Response: ...yes bland, so it fulfils the national curriculum as far as I'm concerned.

Probe: Do you feel that it should do other things then?

Response: I don't think...I think we should be...I don't know really...I mean yes...I mean we've got a task to do to deliver the national curriculum; we've got to do that, but that's not the be all and end all of our job so we should be looking to, you know, give the pupils the opportunity to learn about electronics and to use that perhaps later at Key Stage 4. Does that make sense?

Probe: Yes it does; and do you feel the the software is effective in enabling them to learn about electronics?

Response: Yes, the only thing that is a problem, and I think it's the problem overall, is the backup of it. I think they'll forget it quite quickly and I think they'll probably forget it whatever way you do it but at the...the actual method of learning is very good because the pupils could go back to that and use that again at Key Stage 4. They could use a similar sort of program or that program again at Key Stage 4.

Question 4: Consider that design and technology capability might be defined in terms of how autonomous pupils are in the successful derivation and completion of tasks and that a successful teaching strategy might be a process whereby pupils are gradually weaned into that way of working.

(i) How much do you agree with that statement?

Response:I don't know really.

Probe: Would you like to read the statement?

Response: Let me just have a look at it. Into a mode of working...in other words going to computers and..?

Probe: Well not necessarily to do with computers, but to do with design and technology in general. It's really saying that if pupils are able to, by themselves...

Response: ...gain information?

Probe: ...identify needs, design solutions, put them into action, design the product, evaluate it and do that in an autonomous, self directed way then they could be said to be a very capable design and technologist, as long as all of those parts are done successfully. Do you agree that that is one of the ways...

Response:
Yes, I think that it...I think that that is what we should...we should be going towards. We should be getting pupils to be self motivated within projects and be able to go and find out information, but teenagers aren't like that really are they?
Probe: So you would say that you agree with the statement?

Response: I would agree with the statement but actually getting to...I don't think that it will make them want to go out and research and self motivate themselves.

Probe:What don't you feel will?

Response: The software package itself.

Question 4 (ii): Ok, fine we'll move on. So how important do you feel pupil autonomy is in design and technology projects?

Response: ...

Probe: Do you feel that it's an important thing?

Response: Yes I do, yes.

Question 4 (iii): So looking at the software, you have already started to say that you don't feel that that could perhaps be something that you could do, but how successful has the software been in allowing you to pass control of the project to your pupils allowing them to act with some kind of level of autonomy?

Response: It's...in theory it's very good, but in practice...

in practice it's...you know they will...they will use the computer, because you tell them to use the computer but as I said, because there weren't so many computers...I think if we'd had...if we'd had a computer room that had been, you know, a good area that they had gone into, got the information and come away and you'd have been there for any sort of hitches and things that they don't understand, I think it would be very, very good. But the way that we had it...the way that we've got our computers I think has really...

Probe: So you feel that it has the potential to do that but the practical considerations are the things that stopped that from happening in the main?

Response: Yes I think so.

Question 5: If the software hadn't been available what problems do you feel you might have encountered in delivering the same project and with similar levels of pupil autonomy?

Response: I think that...with...that the pupils were able to go back to the computer and find out information that they didn't understand. It made it easier for them rather than having to come up and wait and find...and you know say, "I don't understand that sir"...

Probe: So without the computer, if you were to offer say a similar amount of choice of different circuits that could be built what problems might that bring out?

Response: Sorry, say that one again.

Probe: The software allows them a certain level of choice; quite a large amount of choice and if you were to try and do that sort of project without the computer what sort of problems do you feel you might encounter?

Response: Without the computer, that would be the problem. The pupils would have to...they wouldn't come up to you as a matter of course. They'd all sort of be like little sheep and they would follow the fast ones. Because they couldn't actually come up to you and get the information because they'd have to wait. I think that's the problem with that.

Probe: So kids waiting; long queues would be a problem?

Response: Yes, I think if you've got all of the computers there, they're working properly, I think as long as they can get on to a computer relatively easily then I think that's...that would work ok.

Question 6: Ok we'll finish that one there. Can you think of any other contexts in which similar types of software might be valuable?

Response: I think there's a lot of areas in design technology where advice given by teachers could be taken over by a computer. Tooling for example, you know, different types of screws, fittings or you know, they could...If they have to actually construct something and then go to a machine...they could go to a machine and look at the types of fitting that were available; that would be quite good perhaps. There are a lot of different applications...mechanisms...making something work with mechanisms or structures, looking at struts and ties. I think that would be...how something could go. I think that could work.

Probe: And in the way that the software guides children through a project, would you feel that that would be appropriate in those sorts of areas. Say taking for example in a mechanisms project; would it be possible do you feel to actually guide children through still allowing some level of choice?

Response: Yes...yes I think it would. The only problem I think would be...I mean it would be good...no I think it would be good. I mean the only thing I would add perhaps, thinking of the structures, it would be good to be able to get them to draw out their own structure on the computer and for that to be analysed and I don't know if existing software packages do that, but that would be quite a good one...or the computer offering an alternative.

Question 7: So that's really the interview over but do you have any further comments?

Response: No, no not really.

15 Minutes

Appendix 3.2: Interview Transcripts - School B

End of Trail 1 Interview

School B, Teacher A

Question 1: Have you taught electronics before to this age group?

Response: Yes but not for 3 or four years.

Probe: What sort of projects have you done with this age group before?

Response: We've done alarms...we've done an alarm project using the thyristor before...did we do...did we do anything else...

[Interview interrupted]

...just to repeat that we've done a thyristor alarm...which we learnt with [Name of University Professor] some years ago at [University Name]; that was a long time ago. I don't think we've done anything else as far as electronics is concerned.

Question 2: Have you taught electronics to any other age group?

Response: Yes we built electronics into a...the old CDT Technology syllabus. We got that to quite a high level. Mainly with individual projects. We also ran two electronics groups the first year that design and technology was made compulsory for key stage 4, but that wasn't terribly successful because we had a lot of the...difficult children go for that option and it rather destroyed it for some of the better ones.

Probe: So what sort of projects did you do with them?

Response: ...we did electronic locks...a counting device for a basketball ring...

Probe: So a broad range of individual projects then?

Response: Yes a huge range of individual projects. We used MF...not MFI...Alpha...is it Alpha? We used the Alpha kits for...to help the kids model it and then tended to design the electronic circuit around the way the Alpha worked rather than understanding the basic electronics. One really good project was counting sounds. That...one kid did really well with that.

Question 3: Concentrating now on the year 9 children, the projects that you've done before with them you said were alarms, do you feel that the way that project ran enabled the pupils to either design a circuit, select components to put in their circuit to take decisions about the electronic components that they were going to use?

Response: When we ran it before they didn't get much chance to make decisions about electronic components. Part of the reason for that was that we tended to teach it very didactically...the electronics part we taught very didactically. Everybody did exactly the same and everybody had exactly the same components and that was sort of what you would now call a resource task and the capability task was then to design what it was going to be used for. So they didn't have that kind of flexibility and we didn't have...you don't have the time when you are teaching a whole group like that to...to actually go through all the different components didactically because do just lose the kids and they totally lose interest; you just can't do that.

Question 4:In general, how would you rate your own confidence and ability to teach electronics as part of design and technology at this level?

Response: Difficult to...I feel entirely comfortable about it, but it's difficult for me to assess that in terms of national standards because I haven't seen anybody else do it.

Probe: But you are comfortable?

Response: Oh yes I'm comfortable with it.

Question 5: What are your perceptions of how your class responded to using the software?

Response: Well they really enjoyed it...they enjoyed it. They all managed to produce a circuit and solder all the components in the right place with only a minimal input from me.

Probe: So you would say that they were well motivated and there was a good success rate?

Response: Oh superbly well motivated and the out...the success rate of the outcomes was brilliant. Whether or not they understand it I don't know. Maybe we can try and find that out later.

Probe: How about the work rate; was that better than normal or worse than normal?

Response: Well it's a very mixed group and the enthusiasm was enormous.

It was frustrating only having one computer and I had quite a large number of kids come back at lunchtimes and after school to make visits to the computer then so that they didn't have to fight with who was going to go on it...and wait for their turn to go on it during the lesson.

Probe: So you would say that the pupils were well engaged in the project?

Response: Absolutely yes.

Probe: In general do you think...do you feel that they felt that it was an empowering situation or a confusing situation?

Response: Undoubtedly empowering, undoubtedly. The reason why it was so empowering was because they didn't have to stand around and wait for me to tell them. They could go to the computer...and those that twigged that the computer was really helping them would then pass information to others...and they'd realise that they could go to the computer, find out and they could then go to the technician, ask for the components, solder them in, get it all on and they didn't have to wait for me to tell them what to do and they didn't have to come and ask me questions. It was brilliant as far as that's concerned.

Question 6: What are your feelings about the use of this software?

Response: That it should be available for all schools as soon as possible. I mean it's fantastic. It's the best piece of soft...it's the only piece of software I've ever used with a group that has actually been easy to use and has made a significant contribution to the kids learning without me having to run around even faster than normal. In fact it saved me enormous amounts of time, it liberated the kids and its enabled them to make progress...in spite of me sometimes.

Probe: Would you say you had less or more control over the teaching situation?

Response: More control...I had more control in the sense that I was under less pressure than I would have been without the software program. I was able to actually sit down and discuss the fault finding process with some kids while the others were actually able to get on and manufacture the circuit on their own.

Probe: So you would say that you had more time to support pupils in their work?

Response: Absolutely yes...yes.

Probe: How do you feel about the sequencing of the content in the software?

Response: Quite happy...I've got no problem with the sequencing. I like the input, output ...sorry input, process, output and the way they are led through those stages and they have their various options under those stages...I mean that was fantastic. The only little niggle I've got with the software was that once the kids had been into a particular section of the software and made their decision, if they had forgotten to print off they couldn't get back in and get another print so they had to start borrowing somebody elses to see what to do.

Probe: How do you feel about the level of language that was used in the software?

Response: It was ok for me.

Probe: Was it appropriate for the children in your class?

Response: It's difficult...difficult for me to make too much of a comment on there because I haven't actually looked at their design folders yet. Also one mistake I made was I didn't get them to write up what they were actually doing with the software at the particular time they were engaged in the software and getting them to write that up afterwards...with a time gap afterwards was very difficult. What I should have done was made them go for one visit, print it off and then...then sort of make a little comment about what they did and what decisions they made and so on, so they could include that in their folder for homework. Whereas, they were so desperate to get all their visits complete and all the components together and see if they could make this thing work, they were...it was quite a difficult thing to manage and we'll have to improve that .

Probe: Did it change your pedagogy at all; did it change they way that you taught?

Response: Oh yes because I was able to be a lot less didactic and much more...I was able to release the kids to be engaged in the task instead of actually sitting down there making them listen and write things down and make notes and so on. They were able to go and do something on their own at their own pace. Those that were quick could rush through it fairly quickly and get on with it. Those that were a bit slower had problems with the revision bits and had to go and ask someone else who knew how to do it rather than wait for me or sometimes they'd ask me.

Probe: Did you find it and empowering or confusing situation?

Response: I found it empowering, definitely. It made the presentation of the electronics part of the project...getting across what they were required to do with the electronics part of the project much easier, more effective and a much better experience for the kids.

As I say, I'm not quite sure how much they'll remember of what they've done and what the components do and this sort of thing, but that, at key stage 3 I don't think with year 9 is that important. It's more important that they have a successful experience with electronics and that they actually remember what they've done I think, because it's about designing and making and you can't expect year 9 pupils...I don't expect year 9...all year 9 pupils to retain all the detailed knowledge that was necessarily involved in that.

Question 7: Did you use the facility to monitor pupils progress with the program?

Response: Yes we used that for working out what components we needed, which was very useful...and I also used it to check whether children had sort of used it correctly and I found a few mistakes. Some people had got logged on with different spelling mistakes. They had answered it wrong so they had actually got a couple of entries in there. That actually was

useful in a couple of instances in that when they forgot to print off they could go back in to the other one they'd made a mistake and do that one.

Probe: Would you like to see any other information provided?

Response: It would be nicer for the more able students to be able to understand how it works.

Probe: We can get on to that in a minute, but I'm really talking about information that you require when you go to the software as 'HyperTeacher'

Response: Oh right...oh no I don't think so. I think that was fine. I don't think there were problems with that at all. It's more important that it's an effective and reliable tool for the kids than it is for me.

Question 8: Would you like to continue using this software with further groups?

Response: Yes Please.

Question 9: And now to go back to your previous point, what changes would you like to see in either the content or structure of the software?

Response: For the more able kids I would definitely like them to be able to understand...

[Interview interrupted] ...what was that one again?

Question 9: What changes would you like to see in either the content or the structure of the software?

Response: For the more able kids, it would be nice if there was a section enabling them to understand what is going on in the circuit and also possibly to make changes like for example the software only allows you to use an LDR one way around. It would be nice if there was a section whereby they could actually change that so that the LDR comes on...I can't remember which way round it is, but one way the LDR comes on or triggers the circuit if it suddenly gets dark...for breaking a beam, but other kids want it to be...the circuit to come on when someone has switched on a light so just changing that...I forget what you call it now...the input section round, they could possibly do that. It would be nice if there was information like that on there.

Question 10:If available would you use software of this particular type in other design and technology projects?

Response: Absolutely...

Probe: Not just electronics projects...

Response: All the time. I mean it's a really powerful tool. The kids were able to use it with only a minimum of supervision right at the very beginning to show them how to get in and how to get out and after that...but the nicest thing about the whole thing was that when the kids were actually using the computer and that software none of the kids played about with the computer or used it for anything else at all. They were totally engaged in that particular piece of software with a specific purpose and they didn't require any supervision at all and they were helping each other in relation to it...and I've never been able to use a computer in a school situation where I've had that positive atmosphere and way of working with the kids.

Question 11: Have you used any other educational software?

Response: Not more than once no.

Probe: What was that?

Response: We used a BBC program for helping the kids to draw, but then we had problems getting that...with a colour printer and it was such a low level that the actual drawings that the kids could do didn't give them any kind of positive feedback, so they quickly lost interest in it. The computer was interesting because they were first introduced to it but once they got their outcome from it that didn't appear in their folder because they didn't think very highly of it.

Probe: Are you still using that?

Response: No.

Question 12: Is there any other educational software available that you would like to use?

[Interview interrupted] ...So the question was is there any other educational software available that you would like to use?

Response: I'm sure there is but quite frankly I don't have the time to sit down and go through it and find out whether it's useful and if I don't have the confidence that it's going to be child friendly or student friendly anyway...so I'm not that willing to make the time.

Question 13: OK, that's the major part of the interview, and just finally, do you have any further comments?

Response: Can we please have it commercially available as soon as possible I think is the only other one.

16 minutes

End of Trial 1 Interview

School B, Teacher B

Question 1: Have you taught electronics before to this age group?

Response: Yes.

Probe: What sort of projects have you done at this level before?

Response: The alarm

Probe: That's the project that...

Response: That's the main project yes...and...years ago I think we did a transistor circuit as well.

Question 2: Have you taught electronics to any other age group?

Response: Yes.

Probe: What sort of projects have you done with them?

Response: 'A' Level...individual projects...using the alpha kit, modelling, with the...using the PCB library on the Mac and photo-etching and doing things for <school name>... for a handicapped school.

Probe: So would you say that was mainly propositional work; ...individual work?

Response: Yes, individual work...mainly individual work...and basic things with key stage 3...fuse testers and water sensors and things like that.

Question 3: Ok, if we look back at the first question, when your answer was that you had done this kind of alarm circuitry with year 9 before, do you feel that the projects that you have done with them before enabled the pupils to either design a circuit, to select components to go into the circuit...

Response: I've never done it with that group before...

Question 3 cont.: ...not that particular group, but with...you know, in the previous projects that you've done.

Response: I found that ...having done it before with other groups and knowing the diverse amount of...the diverse nature of the products that they came up with...was a bit of a hindrance. I thought what I really should have done, in retrospect, was to have just introduced them to the program almost straight away.

Probe: Can we just focus on what you've done prior to this. In the project formats that you've done before, have children had the facility...or have they been able to actually take the decisions about the electronics or have they been building circuits that you have given to them?

Response: Oh, right, yes...they've been...a limited choice. Limited choices...more limited than this.

Probe: What were their choices limited by?

Response: Well we didn't...we never used piezos. We didn't use light sensors; too expensive...

and I think...I can't remember actually...I'm trying to sort of think back...but the last one I did they had the choice between the transistor circuit and the thyristor circuit. So it could latch or it couldn't and we looked at the differences between those. So that enabled me to teach them about the transistor circuit which was useful for the theory for...for later on.

Question 4: So in general, how would you rate your own confidence and ability to teach electronics as part of design and technology at this level?

Response: Good...good.

Question 5:Right onto the two major questions now. What are your perceptions of how your class responded to using this software?

Response: ...erm...

Probe: For example looking at their motivation.

Response: Oh the motivation was good, definitely.

Probe: Was that higher or lower than normal?

Response: That was higher.

Probe: What about the work rate; how quickly they progressed?

Response: It was restricted by only having one computer...and it did actually slow it down. Because normally a more prescriptive approach which wouldn't allow them so many options...they would have actually had the circuit done a lot faster, but because they had to wait for the printer to print off the things and then get the components, it slowed it down, but they understood it more...which was better and also they had the choices.

Probe: So do you think that they found it to be an empowering situation or a confusing situation?

Response: They were divided. Some of them...some of them were confused and there were some pupils who found it difficult to follow the words on the screen...because they didn't have the patience, because they wanted to actually get on and do the circuit which was their priority, so they skipped bits.

They didn't look at the...where it said, do you want to find out about something... 'oh no, we won't bother with that, we'll just go and make it', you know..., 'find out what I have to do - go and do it' , which is the main criteria...priority.

Probe: So you feel that they took the shortest route to the end.

Response: I think some of them did. Some of the I found didn't have some of the printed sheets that they should have done...and by the time I'd noticed that they hadn't got them they...it was too late to go back and get them...especially some of the information like on resistors; the colour codes, etc.

Probe: Because that's an optional loop.

Response: That's an optional thing. So it's the optional things that they didn't...some of them just didn't get. They didn't know it existed because they didn't bother to look into it, because they missed those routes.... without giving more diversity...but there were some of them, when they found out, they said to others, 'how do you get that?', and then they wanted them, 'I haven't got that one', and then they couldn't get back again once they had finished the three stages. So the thing that I found the most restrictive was that they couldn't go back once

they'd done the input, process and output.

Probe: If we could continue to concentrate on your classes' perceptions, we'll move onto yours later, what about the success rate during...

Response: It was good.

Probe: Was it better that normal or worse than normal.

Response: Probably better, actually in the end, yes.

Probe: And how about the way that they engaged in the project?

Response: They all enjoyed it...they...yes they did well. They were very enthusiastic, especially towards the end when they were getting things together. There were periods when they weren't engaged as well, and that's when they were waiting for the computer.

Question 6: So, to move on, What are your feelings about the use of this software?

Response: I think its excellent. I think I'd like to carry on using it.

Probe: Do you think it gave you perhaps more or less control over the teaching situation?

Response: I found that they still relied on me a terrific amount to interpret a lot of the things. They...they didn't have the sort of literacy or the...concentration. They couldn't focus enough to actually get it all form the screen, that had to actually come to me and ask me things. There were certain things that they still didn't understand until they'd actually gone through it with me. So it wasn't as though it was sort of like, most of the electronics is sorted out there. There were still a lot of questions to be answered.

Probe: How do you feel about the level of language that was used with the software?; was it appropriate?; too high?

Response: No I think it was, I think it was right. I just think the particular class had a low literacy level. In terms that there were quite a few English as a foreign language...you know, just come to the school who couldn't...who would have had trouble with any project to be quite honest and I think maybe, in retrospect, it helps them.

Probe: So using that software, was it...did it make the situation constrictive or did you find it supportive?

Response: At first I found it restrictive because I approached it in the wrong way. Because I gave them very free options on needs. So they thought of a lot of different needs...not having gone through the software beforehand myself fully enough...so they were thinking of a lot of different applications...and...with a lot more scope then when they come to the software then they found...find that they can't fit theirs into that pattern. So...for instance the door and draw switch can have a lot of different applications and the micro switch can be used in a lot of different ways which it would be applicable for. So what I had to try and then do is to interpret that and say, 'well don't give up on your need...lets work out which is the best switch'...and then they say, 'oh, but that's a window or door switch, that's not what I am doing'. So that's when the confusion started. And that was my fault because I didn't...didn't investigate fully, before we started, what...I let the thing take...go itself...

Probe: So the project became broader than just security alarms and turned into...

Response: The project was broader to start off with. Gradually what happened was quite a few of them changed their ideas having seen the software on the thing. So they thought

immediately they were going to do one thing and then...and it wasn't security alarms...it was like water sensors and, you know, lord knows what, lots of other different things and then...you know, which is how I'd approached it before, you see, with a wider...because there's a lot...the thyristor can be used for a lot of applications. And then when they saw the things their reaction was, 'oh yeah, I think I'll do that instead', so it changed their ideas and then they narrowed it down to those...those options that were given to them by the computer. Which I didn't like at first, but having done it subsequently, I have actually used it...just by introducing them to the computer and they have got on fine without having to...without having to get them to think too...laterally.

Probe: Did you find that it gave you more time or less time than you would normally have to support pupils while they were working?

Response: More time.

Probe: You had more time to talk to the children?

Response: Yes.

Probe: Do you feel that it changed your pedagogy at all?; did it change the way that you taught or did you teach in a similar sort of way to normal?

Response: Similar sort of way. I still had to do demonstrations and individual.....

Probe: How about the sequencing of the content in the software? ; was that appropriate in the way that it was sequenced?

Response: Yes I think so...it's really only getting back to things...and that's why, you know, I used the...the reset option far too much, because they wanted to go back and revisit things.

Probe: So in general terms, did you find it empowering or confusing?

Response: As I said for some...from my point of view as opposed to the pupils?...I feel it was a learning experience for me...and....

Probe: So initially confusing...

Response: Initially confusing and when I'd got used to it, it was empowering.

Question 7: Did you use the facility to monitor the pupils' progress?;...you know the facility on the program?...

Response: Not fully enough...not fully enough...

Probe: But you did use it some of the time?

Response: Yes. I found because it was a difficult start, because they were changing their minds and...I was obviously leading them through to try and fit the software to their projects, they had a limited amount of things. Nobody used the light sensor. So most of them had the same thing. Most of them actually just picked the...there was one picked the pressure mat...most of them picked the micro switch or reed switch which was quite limiting for them I suppose. But the micro switch can fit most projects.

Question 8: Ok, the next question is largely superfluous in this situation, but If available would you like to continue using the software with further groups?

Response: Yes.

Question 9: What changes would you like to see in the content or structure of the software?

Response: ...can you just stop a minute? I want to think about this or don't you want to do that?...

Probe: No don't worry we can just let the tape run...

Response: ...let the tape run...

Probe: You've already talked about not being able to get back...

Response: Yes, that's the main thing...I did like...when I got to know it I did like it a lot better...the bits were missing at the end. The circuit...things about circuit diagrams...which the kids were pressing to try and find out...I had to back it up with basic electronic...module type input with the overhead projector...maybe some of that could be in...like in a library sort of section...no actually having said that, I mentioned to you before that the actual light sensor one I think is leading them up a dodgy...I know you said that there's a...there are some paths that you can take that don't work...you've got to explore them in order to realise that they don't....

Probe: For the benefit of the tape, we're talking about the fact that if you build the light sensing circuit then it's drawing current all the time...

Response: You've got to have a power source to light it.

Probe: yes, it won't be a totally effective product because the battery will run flat quite quickly.

Response: Yes, and I think that introduces...it...if they are not very aware of that...if they are aware of that...you make them aware of that and if they can get away with it they won't do it. But if they are not aware of it and they go and make it then they realise that at the end they've got a...something they can't use. Which in...you know, some people would say its not for them to get something that they can use necessarily but it is important for motivation for subsequent years. If they take something home that they are not going to use at all...admittedly they could have other applications for that if it followed an extension project, but they're not necessarily likely to because they go off and do some other part of technology.

Question 10: If available would you use this type of software in other design and technology projects?

Response: Yes.

Question 11: Have you used any other educational software?

Response: Not of this type.

Probe: Of any other type?

Response: Well...yes I suppose we've used the PCB libraries worked out for the alpha kit, so we've done modelling.

Probe: So what were your opinions of that?

Response: That was good for the 'A' Level pupils because they had that level of thought and knowledge and so they could use them and it was quite, sort of, flexible. I think that's about it.

Probe: Are you still using it?

Response: Limited amount...it depends really...I mean, unfortunately they don't...none of them pick the micro electronics module for 'A' Level at the moment and the basic electronics doesn't actually involve them in that sort of thing.

Probe: So any other educational software, generally, have you experienced?...across the breadth of design and technology...

Response: Mainly, sort of like, desk-top publishing. General packages, not sort of specific...

Question 12: Is there any other education software available that you are aware of that you would really like to use?

Response: Lego Dacta...we would like to have a go with. We would like to get some CAD/ CAM machines in to experiment in that area. But that's all I think.

Question 13: Ok, so that's really the end of the interview, but do you have any further comments that you would like to make?

Response: ...no.   -   17 minutes

End of trial 2 Interview

School B, Teacher A

Question 1: In considering the software what sort of task do you think it is best used to support. There are three choices here, either:

a contextual task which is very open and leaves most of the design decisions to the pupils;

or a framed task which has some constraints but leaves the significant design decisions to the pupils;

or a specific task which is tightly defined?

Response: The framed task, definitely.

Probe: The second one.

Response: The framed task, yes. At Key Stage 3 if it's too open the kids can't...I wont say can't...the majority of the children have difficulties in deciding what to do and they don't necessarily have the background knowledge. I like to use this as a...this program to actually show them electronics. I don't...and to then ask questions as a result of having used the electronics and then go over the theory of it afterwards, rather than hit them with too much theory first and then let them go at it openly. If you close it down too much it doesn't give them the freedom to personalise what they are doing and the motivation is not so strong.

Probe: So you would say that you have used this software to support a framed task?

Response: Yes, in a framed way.

Question 2: The current national curriculum divides design and technological activity into three main categories. Which of these three categories have you directed most of your teaching towards when teaching this project, either:

to investigate, disassemble and evaluate products and applications:

a focussed practical task in which pupils develop and practice particular skills and knowledge;

or a design and make assignment in which pupils design and make products?

Response: What we've tried to do is to use the program as a sort of...as a focussed practical task, but it's a focussed practical task that is part of a design and make task. It's not...it's not just a focussed practical task on its own because...and its not a design and make task on its own and I sometimes worry about these sharp delineations of tasks and I don't...I think if we go down that road all the time it's not always helpful. So they are doing a capability task but this is almost a focussed practical task that is part of a capability task.

Probe: So could we say that what you are describing is a framed task. There are some constraints but, viewing the project as a whole, they are actually designing and making a product, rather than, for example, making a circuit.

Response: Yes absolutely, absolutely.

Question 3 (i): In considering the national curriculum programmes of study for Key Stage 3 how well has the software performed in allowing pupils to develop their capability in designing and making products?

Response: It's...to a certain extent it's freed them from the...sitting down and learning about electronics...having to carry out a lot of research into various components. It's enabled them to look at what they want to do and then it's directed them towards a specific area as to how they can do that rather than the teacher having to do it, and using time to do it, or them having to look through books and catalogues and whatever to find out for themselves.

Probe: So would you agree that the focus of the way that you have run the project is...the focus of the project has been on the product rather than on specifically, for example, the electronics.

Response: Yes, but not only that. The focus has been on the product leading to a design and make task but it's also helped them. It's given them a desire to know more about electronics and has helped in them going through and being able to teach them about circuits, the way they work, volts, amps, electromotive force, all this kind of thing; they want to know about that because they want to know how it works because they've got into it and they've got the motivation to want to actually produce this thing and the motivation of the students is quite considerable. They have become absolutely desperate to get the work completed and finished and have their product finished and working.

Probe: So could we perhaps say that there were two parallel agendas with different motivations. The children want to design and make the product and you want to teach them something about electronics.

Response: Yes and they come together very well.

Question 3 (ii): So the same question again, how well has the software performed in providing teaching and learning opportunities for yourself and your pupils?

Response: Excellent, it's been excellent, absolutely excellent. It does a number of things. It teaches them something about electronics, it enables them to solve the problem that they've been set in terms of what they are designing and making for their capability task, it provides the motivation, it frees them up from having to wait for the teacher, it also enables them to experience a different teaching and learning style in that they are not sitting and listening to the teacher going on or reading through books, they are actually engaging and interacting with something.

Question 3 (iii): And again considering the national curriculum programmes of study for Key Stage 3 how well has the software performed in fulfilling the specific requirements of the programme of study?

Response: In that sense I haven't...I would like to spend more time looking at that to give a really effective answer but certainly it's helped them in their use of IT.

Probe: If we were to consider the programme of study, for example for systems and control.

Response: Yes, for systems and control it's marvellous. It enables them to develop a system that responds. It enables them to understand systems in terms of input, output...input, process, output, but more importantly for me it's given them a confidence in using IT that they take to other...other aspects of using IT.

Probe: So do you feel that there is generally a lack of confidence in using IT at that level in this particular school?

Response: Generally yes there are some students that are experts at Key Stage 3. There are...

Probe: Why do you think that is?

Response: Because they have got them at home; because their parents are interested; because they have opportunities and they have been working with IT for a long time. There are others that are very intimidated by it because they have only had two short programmes within the school and they haven't had the opportunity to actually get into...to react... or to interact with a computer on their own to any great degree. There are others that don't have a very high level of skill but are very keen to develop it because they sense the importance of it and I'm sure there are some of them that have gone home and said to Mum and Dad, "look we desperately need a computer", and I've had some feedback from parents evenings that we are buying computers and so hopefully that will develop even more.

Question 4 (i): Ok, I'll show you this statement here because it's quite long, but consider that design and technology capability might be defined in terms of how autonomous pupils are in the successful derivation and completion of tasks and that a successful teaching strategy might be a process whereby pupils are gradually 'weaned' into this mode of working. How much do you agree with that statement?

Response: I agree with that absolutely. I agree with that absolutely. Our prime objective here at Key Stage 3, and the early part of Key Stage 4, is to try and make the children as independent, or rather independent learners as far as that is possible and I'm always on at the children to try and develop this ability and use the teacher and technician as consultants rather than, "what do I do next?". I get very angry with them when they say, "what do I do next?". They should be thinking about that for themselves.

Question 4 (ii): So you obviously think that pupil autonomy is a very important thing in design and technology.

Response: Absolutely, I agree with it completely.

Question 4 (iii): How successful has the software been in allowing you to pass control of the project to your pupils and allowed them to act with an appropriate level of autonomy?

Response: As far as the electronics part of the scheme of work we use, it's been brilliant. It's been the best thing since sliced bread or the wheel.

Question 5: If the software had not been available what problems do you feel you might have encountered in delivering this project with similar levels of pupil autonomy?

Response: There wouldn't have been...there wouldn't have been anything like that level of autonomy. It would have had to be a pure focussed practical task. With the normal difficulties of trying to find extension tasks for the more able while you support the less able. One of the things that this computer program does is it allows the children to interact with each other and if the teacher is busy, the less able will probably go to a more able, or more computer literate student and ask them, just to help them to get over a particular problem.

Probe: So focussing on those problems, again you say you would have to do it as a focussed practical task, would you like to give reasons why you would have to do that rather than allowing that level of autonomy?

Response: You'd have...what the computer does...it allows the children to see what components are going to be used, where they are fixed, what they do and you don't have to teach that in a formal way as a focussed practical task. Because the computer shows them how to do it and they come away with their printouts, they want their components and most of the majority of the kids, even the less able, are able to take their components, they know where to put them, so long as you actually do a focussed practical task on soldering then they are liberated and they can find their way through and put together the circuit and get it working with just consultations with the tutor and the technician just to ensure that they know...that they've got it right if they are not confident or that...or that if there's a problem they can just ask quickly how to solve that problem. One of the really positive things that's come out of it

is the fault finding at the end because a number of the children...or not ...only a few of the children managed to put the circuit together and have it working straight away first time. None of that is the fault of the programme. The programme is fine. The fault of that is when they are doing their etching, or when they are soldering, or when they are putting the components in they make mistakes in terms of little marks on the board and so on and that actually leads you...it creates a desire amongst the children to actually learn how to fault find because they desperately want their circuit to work and they want to know how to find out why it's not working. So that leads into another focussed practical task which you can do on fault finding but they do need a lot of help with that as well.

Probe: So again I'd like to focus on the problems. I mean could you perhaps list some of the problems you might have if you were to try and do this project with the same level of choice, the same level of pupil autonomy, but not with the computer?

Response: ...right...

Probe: I mean you've obviously refrained from doing this in the past for specific reasons...

Response: We have done something similar in the past but the problem is the knowledge; getting the knowledge across to the kids about the components and where they go and what they do. When you actually sit them down in a group and you go through this using an overhead projector, or using a blackboard, or using printouts and you explain everything, it's a very dry form of teaching and it's very similar to sitting in a classroom and learning about something and in this particular school we...most of our children don't respond well to that type of teaching and learning. Most of our children want to be doing, they want to try and work on their own, they want to try and be independent and as I said I think that's absolutely vital and try and encourage it and that's what the computer does. It presents everything in a beautiful way. They press a button and the picture of a component and information about the component comes up and if they don't want to read that they can press another button and move on to somewhere else. When you are actually teaching that you have to have the whole group together. You can't go around and teach everybody individually, but the computer enables you to do that.

Question 6: So in considering that, you've now used the software twice to actually deliver this project with choice and autonomy for the pupils, has the nature of the problems which you or your pupils have experienced changed?

Response: There have been a lot less problems the second time around. It's been much easier basically because the first time around most of the problems I had were in managing the use of the programme and having thought about that and concentrating on ways of trying to avoid that. Specifically I have been much more careful about how the children log on. I have made them make a note of exactly how they've logged on in upper-case and lower-case and all the rest of it. So that the problems of logging on have virtually disappeared this time. I have also told them that this programme is there to make life easier for them and to help them and they have responded to that and, therefore, they haven't messed about with it and tried to sabotage it and if a child was actually doing something like that I have noticed a couple of occasions when other children have come over to them and said, " look, hey come on, don't spoil that for the rest of us" or, "Hurry up, don't play about with it. Somebody else has got to do it". From experience the management of it has been much easier second time around even with only one computer.

Probe: But introducing the software to support this project, it introduces another problem in that now you've got to manage the software?

Response: Yes and that's difficult the first time around but, like anything, once you get used to it you can isolate the problems, solve them and it then makes it a great deal easier.

Probe: Has having only one computer been problematic still this time?

Response: It's been less of a problem because I've managed it...I've managed it rather better. What I've actually done this time is while they are actually going through the computer for the first visit and getting their PCB, I've been doing some three-dimensional drawing with them...work with them so that a focussed practical task on three-dimensional drawing to enable them to actually present their ideas for the packaging in the folder in a better way later on in the project. And that has worked very well because while they are sitting...while they are sitting actually doing the focussed practical task on the 3-D drawing they can go off and use the computer and come back without having missed anything absolutely crucial or vital. Once they've done the first visit and they are on their PCB, they tend to spread out a bit, some of them come back at lunch times and after school, and once they have spread out a bit...if they are desperate...if they are in a desperate hurry they'll go to someone else and say, "can I have a look at yours and see what you've done. Is yours the same as mine", and they'll actually perhaps miss a visit or two or catch up on it later.

Probe: But its that initial visit which is the big 'bottle-neck' ?

Response: It's the initial visit that is the problem, yes.

Question 7: Can you think of any other contexts in which similar types of software might be valuable?

Response: I am sure there must be many and I would love the time to sit down and try and work it out, but electronics lends itself very well to that. I would think...I would think in...production of a materials list might be helpful. We have a system at the moment where we do materials order forms for the children which they have to get signed. At the higher levels, certainly at Key Stage 4, a more sophisticated sort of materials order form might be a good way of doing that. The...also informational things like fixtures and fittings and screws and nuts and bolts and things like that where if there was some kind of programmme where a child could have a particular problem like, I've got to join a piece of plastic to a piece of wood, how do I do it? ; what are the ways of doing it ? and they can then actually go through, and be led through the various options and make their decision and come and say, "look, this is what I need". That would be...that would save teacher time in trying to explain that sort of as it comes up and again it's a situation where you don't want all the children around while you tell them about this all the time because some of them are not...they are going to be engaged in different things and they won't want to focus on it. To be able to go to the computer and interrogate that, and find that out on their own would give them that good feeling and motivation and save time.

Question 8: Ok, so this is the interview over really, but do you have any further comments?

Response: Just lets have some more like this, you know, please. It makes life a great deal easier when you've got a versatile tool like that you can actually use, that helps you in so many different ways. It helps with the motivation of the kids; it helps with actually getting the work done; it helps me in terms of enjoying the teaching, therefore I'm more effective; yes, it's brilliant.

22 minutes

End of trial 2 Interview

School B, Teacher B

Question 1: In considering the software what sort of task is it best used to support. Now there are three choices here, either:

a contextual task which is very open and leaves most of the design decisions to the pupils;

or a framed task which has some constraints but leaves the significant design decisions to the pupils;

or a specific task which is tightly defined?

Response: A framed.

Probe: A framed task. So would you like to explain why you feel the software is best used to support a framed task?

Response: Because I think that some aspects of the software restrict the open ended nature of...the nature of an open ended task and I think that they would restrict it by the very nature of the software, but I think it supports a framed task very well. I mean there are...it depends how sort of framed it is or how open it is.

Probe: Do you feel that it is appropriately framed at this level?

Response: I think that we have framed it fairly well with the project that we do but we've got more experienced at doing it and I've closed it down a lot since starting it and I don't think that's a bad thing because I think gradually the products are getting better.

Probe: When you say you have closed it down a lot, have you closed it down to a more narrow frame than the software allows or to the same frame that the software allows?

Response: The same frame that the software allows because it was too open at the beginning. I made...I presented a much too opener task and gave them far more freedom than the software really indicated. So when they came to the software they got confused because they said, "it's asking me this and it's asking me that and I don't understand this because I want to do that". So I tailored the assignment to the software in the second one which worked better.

Probe: It's works better. How do you feel about the framing of it; is it too tight or too broad at that level?

Response: I think it's ok bearing in mind that I had a group that had a small time span to do it in. [other teachers name] group had much longer and I sort have have to really bat along to get things finished.

Probe: What are those two time frames that you work within?

Response: Oh gosh, well four units a year so I can't remember exact...

Probe: So would you have six weeks; twelve weeks; in your groups?

Response: I can't remember, I can't actually remember exactly what it is specifically...

Probe: Percentage wise, does [other teachers name] have twice as long as you or...

Response: [Teacher A] has three groups a year and I have four groups a year...so if it's say 30 weeks or whatever...ten weeks for [other teachers name] and that's...

Question 2: The current national curriculum divides design and technological activity into three main categories. Which of these three categories have you directed most of your teaching towards when teaching this project, either:

to investigate, disassemble and evaluate products and applications:

a focussed practical task in which pupils develop and practice particular skills and knowledge;

or a design and make assignment in which pupils design and make products?

Response: The third one.

Probe: A design and make assignment?

Response: Yes.

Probe: Could you explain your reasons for directing your teaching towards that area?

Response: I think that it's the most important one to develop. We as a department haven't actually addressed investigating, disassembling etc. and evaluating enough and we don't actually do enough of it. It demands that you get the resources in order to do that and that you can support that sort of activity. We haven't actually got the sort of stuff to do that. The resources aren't available. That is something that the department has got to address in the future and I think [other teachers name] would agree with that. The focussed practical tasks, there are obviously focussed practical tasks involved in the project. But they do definitely support, and are integrated into, the design and make assignment. So the design and make assignment is the most important. I mean there is an element of investigating but If you are talking about alarms we haven't done a terrific amount of taking apart alarms and looking at them.

Question 3 (i): In considering the national curriculum programme of study for Key Stage 3, how well has the software performed in, firstly, allowing pupils to develop their capability in designing and making products?

Response: I think they have learned a lot from it. They've been...instead of actually concentrating on the electronics side of it...instead of concentrating on the inverted commas theory side of it, it's allowed them to actually concentrate on designing and they know...with the knowledge they can be taught on the electronics...the how separately and that will come. I've supported it with demonstrations, with techniques and things like that.

Probe: So the software allows them to actually concentrate overall in designing and making a product rather than in learning about electronics.

Response: That's right. Whereas if I'd had been delivering it then most of the time would have been spent with me delivering the electronics and that would have been the main focus of it.

So they have actually been able to get on with folder work whilst they've been waiting to get onto the...there has been a number of activities going on simultaneously, which was good because it helped work the resources so you could have some people using the computer, some people doing the design work, some people starting to experiment with making boxes or starting their PCBs. So there's a lot of different things going on which was good because they support each other.

Question 3 (ii) : So again back to that question, how well has the software performed in,considering those programmes of study for Key Stage 3, providing teaching and learning opportunities for yourself and your pupils?

Response: ...that's a difficult one. I wouldn't...I would say that there are limitations, I'd say there are things that it doesn't do but generally I think it is good at providing teaching and learning opportunities.

Probe: I'm not necessarily concentrating here just on the software itself, but by introducing the software into the project as a whole it has knock on effects. Have you noticed anything in the way that the teaching and learning opportunities have changed?

Response: ...

Probe: Has it got worse; has it got better; are different things now available to you?

Response: I think, as I said, it has allowed them to concentrate on other things; to look at their own projects and analyse what they are doing without having to be taught all the time.

Probe: So you feel that that is important then?

Response: I feel it's important. It's given them a bit more freedom. The actual products, the outcomes, have been better from this than from previously when we've done electronics.

Probe: Better is quite a loaded word. What do you mean by better?

Response: More variety, more creativity and I think the enthusiasm has been better. They've been more highly motivated. That may also be something to do with them enjoying using the computer. It's got this spin off that if they have to use the computer they think it is very important. It's on, right on you know so if you're just teaching them it then it's quite old fashioned as far as they are concerned sometimes. If they are using...going to use the computer to find the information out then use that information...and it's quite a good sort of like kudos thing and that's an important sort of thing to look at. They do enjoy using computers...

Probe: Rather than perhaps looking...I mean the same information could be presented in a text book do you feel...

Response: yes, they would not go to a text book an look that information out of their own accord with the same enthusiasm as they go to the computer and find out what they need to know. I do find though, having said that, that sometimes they miss things and that depending on the pupil...one pupil will sit and read it and another pupil will be just trying to get to the end of the task on the computer and not actually understanding what is going on but be wanting to get trough it. Like it's almost a test to get to the end of what they've got to do. Like playing a game almost as opposed to actually understanding what is happening. So that does have to be reinforced quite a lot and like, "what did it say on the computer?", you know, and, "well go and have a look at your notes again" or "go and have a look at your sheets again".

Probe: So as a kind of rough estimate, what sort of percentages would you feel within your group...are most of them rushing through it or are some of them rushing through it?

Response: I would say that about 60% were using it properly, 30% were just trying to get through it to get to the next stage and, you know, I've got some pieces of paper now I can get it done, and about 10% hadn't got a clue what the computer was about because somebody had to come and say, "press this, press that", There are quite a few special...but mainly language difficulties.

Question 3 (iii): And finally to finish that question off, how well has the software performed in fulfilling the specific requirement of the programme of study for Key Stage 3?

Response: oh lord...

Probe: Well perhaps if we concentrate just on systems and control at Key Stage 3?

Response: I think, yes, it's very good. It has actually...it's gone a long way to doing that. I am very pleased that it's available to us.

Question 4 (i): OK, I'll show you this question because it is quite long, but consider that design and technology capability might be defined in terms of how autonomous pupils are in the successful derivation and completion of tasks and that a successful teaching strategy might be a process whereby pupils are gradually 'weaned' into this mode of working. How much do you agree with that statement?

Response: We're looking at sort of independent learning, aren't we?

Probe: With the autonomy bit, I'm talking more about who has control over the work. So is it completely teacher led; or is it partially teacher led, partially pupil led;or is it, you know, completely pupil led in what task they are deciding to do, they are judging the value of those tasks and perhaps deciding the best way in which to complete them. How much do you agree that capability could be measured in terms of how autonomous pupils are in the process of design and technology?

Response: Oh I think it...I agree with the statement.

Probe: You agree with it?

Response: Strongly agree with it as a philosophy of what design and technology is.

Question 4 (ii): So how important do you feel that that pupil autonomy is in design and technology projects?

Response: It is important. It's not absolutely everything though.

Probe: So what are the other things then that you feel are important?

Response: There is an aspect of knowledge as well as an aspect of the discipline and I think that there's lots of other things and there's also obviously got to be a balance, but generally I think the most important thing is that the pupils are autonomous and that they work through things themselves and that they make decisions themselves and they can justify what they are doing and you get motivation from this. In order to find things out....

Probe: Because projects perhaps become more personalised?

Response: Yes, that's right yes. They lead into different directions which, if the teacher was in full control, they wouldn't be able to do. That's the nature of the subject. It's empowering them to get what they want out of it and to gain their own rewards as opposed to being led by the teacher and saying, "This is what we've got here. This is what I'm giving you and you're going to take it" and a lot of times some of them say, "No I don't want it".

Question 4 (iii): How successful has the software been in allowing you to to pass control of the project to your pupils and allowed them to act with an appropriate level of autonomy at this level?

Response: Very successful. As I said before it has...It's taken away that necessity for me to spend time teaching them because they are finding out themselves and that's been valuable, because they've been going to the computer themselves. So instead of having a group and doing a teaching chalk and talk, which you can only do so much of that, it's allowed me to do that in other areas to support the project. Do you see what I mean? So instead of spending...for instance instead of spending about 20% of the time teaching them about electronics I can...the

computer teaches them about electronics, in their own time, when they need to know it, whereas I can then spend that 20% of the teaching time, teaching them about other things which support their autonomous decisions.

Probe: So you are still teaching then; you haven't absolved control?

Response: Oh no, not at all. I'm teaching techniques about...well construction techniques and also how to use the things that they've been told about on the computer. There are a lot of times where it says...well there is one time where it says consult your teacher isn't there? or ask your teacher?

Question 5: If the software had not been available what problems do you feel you might have encountered in delivering this project with similar levels of pupil autonomy?

Response: Well I said this again before and I'll say it again. If you haven't got it then it ties the teacher up in teaching those things. This releases the teacher and allows the teacher to support the other activities.

Probe: Is it possible, perhaps, to teach all of those areas, all of those areas of choice; is that appropriate that every child gets taught about every single thing and then makes a decision or do you feel that its better that the information that they are given is particular to their own chosen context?

Response: I think...I don't think that you can always teach them everything. I think that they can't always have exactly the same choices. I think that you have to tailor it to their own particular needs for the sake of them keeping their interest. They learn from things that are going on anyway. I don't think every kid needs to know exactly the same information. If it's just given to them and they don't need to know it then a lot of it's redundant information because they don't remember it anyway.

Question 6: So in considering that, has the nature of the problems which you or your pupils have encountered now using the software for this project changed?

Response: Can you go through that again?

Probe: We are now using the software to do the project with this level of pupil autonomy, has the nature of the problems now changed; has this introduced different problems by actually now using the computer instead of yourself?

Response: Well there are problems. We haven't talked about the problems. We could talk about the problems?

Probe: Please

Response: The problems can be sorted out. There are problems, but we have solved quite a few of them by having an ordering system so the pupils can go and find...ask the technician for what they need which is good because they ask for things themselves. They are not just being given a load of things and being told, "This is how you put them in and that's how they work". So it's opened them up like that. But one of the main problems was the...how easy it was for the system to be corrupted and this has caused me a lot of problems. The other problems, as you know, is that we've only got one computer and that's caused a bottle neck with a lot of pupils waiting for it. That has been...unfortunately that has been...those two from my groups has been an overriding problem considering the small amount of time that they've had. With [other teachers name] they've had a lot longer and he can take it more easy and he can say, " Well, you know, eventually you will get on there. You'll be doing other things", but with my group I've had to try and hurry them along. I've tried to hurry them along and push things to get it done quicker has meant that there has been a lot of frustration sometimes over the use of the computer. I don't know why. Don't ask me why but my lot have been very good

at mucking up the software and I think, as I said before, it's to do with the fact that there are...you can't go back and correct your decisions sometimes and don't ask me why but sometimes they can't spell their name right twice and it astounds me that they can't, but I think it's just, as I said, trying to get things done too fast. They put something in that's wrong but they've already pressed the enter, they've already decided that it's...and then they can't get back and change it. For instance, "Have you used this programme before?", "no...oh no I've made a mistake", so what do they do? Some of them have turned the machine off. They've been told, "don't ever turn the machine off", but some of them have done it, because you will always get pupils who will panic, who will not be able to get out of the situation, who will panic and that's caused a lot of problems. I've had floating boxes going round with input, process and output all over the screen for the last few weeks, so that's the main problem. I think that when it's working fine it's absolutely excellent and it has supported the project well.

Probe: Right, you mentioned a bottle neck, or hold-up shall we say. Is that hold-up there with the computer throughout the entirety of the project or is it at a specific point when you've got lots of children waiting to use the computer?

Response: It's all the way through really because we just need more than one computer. If we had three computers that would be fine. It is all the way through. There is always a queue of people waiting to use the computer. Now they have other things to do, but the natural, you know, enthusiasm to get on the computer means that a lot of the time is wasted. You know, obviously, they are doing their design work, they are working things out but I suppose yes right at the start they need to know about the circuit. They want to know about the circuit. It's a main part of the thing and they want to actually get the circuit working. When you've got the circuit working and you can see what it does then you can start to develop other things as well and it takes it on to another stage. When you doing it sort of designing...I don't like designing in theory from the start without actually getting to grips with experimenting and working the materials. I don't think you can ever actually...nobody realistically actually does it.

Probe: So you feel that it's most appropriate if the kids are able to actually, although they are designing a circuit for a context, design and make that circuit and see it work before they move on to the rest of the project.

Response: Yes, I mean if I'm designing something I will analyse it, I'll brainstorm, I'll research, but I'll also go straight to the stores and get something to try things out, to try and experiment. And this sometimes is the thing that is missing in design and technology because they are not allowed those resources to do that. "No you've got to give me a drawing before you've actually worked anything out", you know...sorry, "before you can get any materials", and, you know, you've got to say exactly what it's going to be like. It's like a little test for them. "You guess what we've got in the stores", "no that's wrong, no that's wrong, no we haven't got any of that. Now you write it all down and work it all out", and sometimes they are just totally stuck. So I do believe that you have got to give them as much information and resources as you can make available to them and I think that the computer program is one of them. So actually starting on it quite early and getting them working on it does help the project. Because some of them can't envisage...even if you actually...you'd be quite amazed, even though I've got a demonstration a set of drawers over there with an alarm on and even if though I've got little visual aids with alarms still some of them don't quite, unless they've got that circuit there themselves understand how it works or what's going on and that supports it.

Question 7: Can you think of any other contexts in which software of a similar types of software might be valuable?

Response: In the field of electronics or...?

Probe: Well in in the field of design and technology in general.

Response: It would be nice to have something for mechanisms...to be based on mechanisms.

It would be...that would be good if that's a possibility? The good thing about the electronics is that...I don't know, the conventions and things work well with the computer. You know the circuit diagrams; getting something printed off. They're nice sizes and things and the kids can work on them themselves. They can take something off the computer and go and do it but with mechanisms whether they...you would need like kits...you would need to teach them something on the computer or get some information on the computer that they can translate into a kit. So it's quite heavy on resources.

Probe: Because, perhaps we could say that electronics is thought of really as two-dimensional and often static, whereas mechanisms is very three-dimensional and always moving?

Response: Yes and I don't think you can...you can black box electronics, to a certain extent. A bit more than than you can black box mechanisms. You've got to get into mechanisms and you've got to mess around with the displacement of parts and there's a lot of different other things which might be difficult to do on a computer. It would be nice to see a mechanisms project supported by software. The other...more electronics things would be good.

Probe: You feel that the computer is an appropriate way of...

Response: I think it's good and also staged to allow progression through the years. So maybe short ones in year 7, you know, getting up to, or going through the years to show progression with more and more...I mean I do think it is probably, in reflection, I do think that it is probably too restrictive for older pupils, mainly for year 9 I think it probably is, but I've...

Probe: So you think the software is too tightly framed for year 9?

Response: Well it's more tightly framed than I would have chosen to begin with, but because it's been successful I've been quite happy with it. Do you see what I mean? My natural inclination is to go with things that are more open-ended. So I started the project very open-ended, but having used it the results that kids have been...they've actually opened it out themselves you see? So they've taken things and used them. So I don't know. I'm still inclined to think that it's a little bit tight.

Probe: You've not revised your opinion at all; you still think it's too framed for year 9?

Response: Yes.

Probe: Does that apply to the whole ability range in the particular context here?

Response: No it doesn't. But you've got to pitch it at a certain...you know have to pitch it somewhere, don't you?

Probe: Right, so where do you feel it's been pitched?

Response: I think it's been...I think it's been pitched in the middle. I think some of the kids could have done without me at all. It's certainly not been pitched at the lower end.

Probe: Has it been possible for you as a teacher to open it out for those children that need it or has the software prevented you from doing that?

Response: I think the software has to a certain extent yes. Because they've got a definite thing. What I don't like about it is the fact that you've got a bike you know in the start as an example you know and a door and a pressure mat and things like that. That's what I still can't sort of like...because that's like just leading them into...you know, you've got a choice, bike, pressure...and even if they think of something themselves when they see, "Oh yeah, there's a bike there. I've got a bike, I'll do that". So they sometimes change their minds. Originally they were going to do it to help their Granny, or some real need, you know, they get to the computer and see a little bike there and say, "Mmm, I like that idea, I've got a bike. I'll do

that instead". You know what I mean? It's a set thing a set example.

Probe: So before they come to the software have they identified a context within which they are going to work?

Response: They should have done. I changed it this time you see. The first time I said decide on a context and went through different needs at looked at real needs and got them to identify needs and then they went to the computer and got totally confused because they had a restricted menu to choose from. So then we had to match the right system with their needs, which was an awfully difficult job. This time I presented them with what the computer was going to give them and said these are the options that you have got. Now if if you want to change these or if you've got a need which, you know, is really good we can adapt some of these to that. So for instance, I don't know, if your beautiful Ming vase or whatever your Mum's got is in danger of being nicked what's the best one. Maybe you could use a micro switch. A micro switch so that when the Ming vase is taken off the micro switch it works. Things like that. Now they might decide that they are going to do it for a Ming vase and they get there and say, "Pressure mat, someone's treading on a pressure mat. That's a good idea I'll do that", and they change. There's a bit of sheep business, you know. So that's the main problem. That and reliability are the main criticisms.

Probe: The reliability of course is because it's only a trial piece of software but I'm interested to hear about the actual visual information that's given. You feel that it's that visual information, for example the picture of a bike, do you feel that it would be more appropriate, say if we were talking about for example the tremble switch here as an input, it's just a description of what the tremble switches do rather than an example of an application?

Response: Yes I think that would be the case and that let the teacher talk and pull out of the kids their own things and then with that menu of different devices they could use without a menu of different needs, because as soon as they see that menu of different needs then they go for those.

Probe: It can change their context?

Response: It can change their context or they don't understand. They say," Hold on a minute I want this Ming vase thing but it just says window and door", you know, and that's for a window and door and I say, "No that's not for a window and door you can use a micro switch for all of these things really. The micro switch can be for everything. A micro switch is a universal thing you know and it gets quite confusing you know. You can get like dual messages.

Question 8: That's good. So do you have any further comments?

Response: No.

30 Minutes

Appendix 3.3: Interview Transcripts - School C

End of Trial 1 Interview

School C, Teacher A

Question 1: Have you taught electronics before to this age group?

Response: Yes.

Probe: What sort of projects have you done with them?

Response: We did...when we covered the SATs project...which we did a trial actually I think with Middlesex again at that point...we did a similar control type circuit with the use of an SCR and so on and so forth. So we did that with the same year group but we felt that there wasn't quite as many input and output variables as with this project.

Probe: That was a bag alarm wasn't it?

Response: Yes, that was right, yes.

Question 2: Have you taught electronics to any other age group?

Response: Yes...from 11 to 16.

Probe: What sort of projects? A wide range of projects?

Response: When we have been doing GCSE Technology for instance, when that was underway, I would be also teaching the electronics component of that syllabus. So it would be ULEAC electronics module, ranging...so it wouldn't be micro-electronics, but it would be up to and including various logic gates and all that sort of stuff.

Probe: So the sort of projects in most groups were individual...

Response: oh no, so in other words there would be that component that would be taught as theory, supported by the electronics kit and whatever and then it would be...if the child had chosen to do their major project at the time with electronics then we would support that.

Question 3: Concentrating now on this particular age group, year 9, and thinking about the projects that you have done with them before, do you feel that those projects have enabled pupils to either design a circuit or at least select some components, or to take any decisions about the electronics that they used?

Response: Previous projects?

Probe: yes, previous projects.

Response: Er right...so in other words make decisions about...

Probe: About the components that they used.

Response: By decisions, do you mean have they got a choice?

Probe: Yes

Response: ...I would say limited. A limited choice. I mean there's...in terms of...that way that this...the control element you set with the one that you've done, the Thyristor, that stays constant...but that varies...the variable is the input and output. We have tried it before but with a much less choice. To do with cost etc. So in that sense, previous projects would offer minimal choice for various reasons. It might be cost, it might be to do with the fact that a

particular type of group, you might want to contain and constrain them for practical reasons in terms of their learning and understanding. In other words with too many variables and they might not get a handle on what the essence of what was happening. It depends on the ability of the group as a whole.

Probe: So that would be a decision that you would make based upon the ability of the group?

Response: Yes.

Probe: Was there any kind of management consideration...you mentioned cost but were there any other things that stopped you giving more choices.

Response: I would guess that some of it could be to do with teacher experience. I suppose that would probably be an element of it... whether they had got that kind of thing.

Probe: Do all teachers within the department teach electronics?

Response: If we stay...in key stage three?

Probe: In key stage three.

Response: It depends...it depends on the way that the timetable works. We haven't got an electronics person...we all share that particular thing...is that OK?

Question 4: Yes that's fine...absolutely fine. How would you rate your own confidence and ability to teach electronics as part of design and technology at this level?

Response: I would say I was competent.

Question 5: Right onto the two major question of the interview now. What are your perceptions of how your class responded to using the software?

Response: Positive...I can go through it if you want?

Probe: Please do.

Response: They em...put it like this...I mean the challenge...I'll link the question because there's something I want to say. The actual way that I went about teaching this particular group was probably different to how I'd approached teaching any other group when I'd dealt with electronics. I allowed the software to act as the guide and the...

Probe: Could I just stop you for one moment there.

Response: I'll get back to the question here.

Probe: I would like to talk about that in the next question.

Response: Right, what was this question then.

Probe: Could we concentrate in this question on how your class responded and then well come onto your perceptions later.

Response: They were mo...oh I got you we'll do it...they were positive about it. They were interested in using...they like using computers anyway. They are familiar with the format of the Mac. They were interested in the methodology of working through the various sort of cards and so on; they liked that. They were motivated by that. They were motivated to go through the various stacks and to look at the various components and so forth; they enjoyed that. They enjoyed the fact that they could produce a hard copy and actually then use that as

part of the presentation on their A3 sheets and so on. They were probably motivated by that fact that the PCB layout, for instance, was real full-size, where they could actually use that as a direct reference to actually producing the real PCB; they liked that, they enjoyed that. They enjoyed the fact that everything was measured correctly so that they could...in terms of fulfilling the mounting of the components and so on; they enjoyed the reality of that.

Probe: So in general terms their motivation was very good.

Response: Was higher than normal.

Probe: What about their work rate, how they progressed through the project. Was that higher than a similar project or lower than a similar project or the same?

Response: Difficult to answer because as I say it's not the sa...In some respects there was probably a certain amount of dwelling on elements of the project where if it were more teacher led, which quite often is the way that I have done it in the past, might not have been dwelt on as much. It might have been, the way I would have taught it possibly in the past, would have been much more potentially teacher led with an element or experimentation, but I would have probably driven them a bit quicker.

Probe: So which areas did they dwell upon then?

Response: ...er...I mean that's what I saying, If I was to do it again I wouldn't allow the dwelling to occur so much but they probably dwelt on areas...for instance certain students, I could pick out the personalities, the...certain students...I mentioned (pupil name) because she will occur on your data, she was very, very keen on working on the computer as opposed to working on the practical element of the circuit. That said, she did actually make a nice circuit, but she was very fastidious in ensuring that all the potential of every single piece of card that she could look at, and any interaction that was available, she actually would go through; whereas other students would only go for the basic way through. There were sections where you could go through and, like look at the resistor and print out the picture of the resistor and so on and so forth, or you have the switch where it's clicking and you can listen to it clicking...that sort of stuff, she was...and to what level she actually was understanding what was going on I am not sure. And in fact that is the question that I've got for the whole thing...and I've got an all boys which I'm going to teach it to next and probably when I do it with them I could actually do it differently. I actually might have...I might include...as well as having the sort of child centred aspect, the way I've done it in this particular experiment...I will probably do some focussed teacher led type inputs in a more structured way than I did here. But you know that said, the students here do understand how the thyristor works. They actually understand that now. Because, you know, I was doing that with them the other day and they did it; they understood.

Probe: So in general the were fully engaged in the project?

Response: Totally engaged. There is no student in the group that isn't engaged in the project.

Probe: Obviously in this situation, for the benefit of the tape, you have plenty of computers. You didn't find a problem with computer numbers?

Response: No. Funnily enough though, what did happen was we made...as a department we made the decision to actually decant, if you like, about three computers into the individual other teachers classes which kind of made it slightly difficult for me to continue because then the student had to go into that classroom and get the computer on the trolley but no there was never really a problem.

Probe: How about the overall success rate with the project? Was there a good degree of success; did they get their circuits completed?

Response: Oh they've all got their circuits completed, it's just the matter of...mind you they've only just finished it really last week. So they're in the fault finding process, but I know for a fact that, speaking to other people that, you know, it's not often that they all work first time, particularly if they haven't had that much experience with electronics.

Probe: So overall do you think that they found it to be an empowering situation or a confusing situation?

Response: Well that would vary on the student. Some students probably have picked up on the fact that they are producing a folder with information about electronics in it which they are to collect and are not mentally engaged necessarily in the control sort of theory and so on and how the circuit works. There may be...I'm not sure on the percentage for that...there may be as much as 25% of the students are like...

Probe: ...are confused? Would be confused...

Response: ...but they would probably think that they were not confused. They would probably think that they had done... that they had picked up mentally what they were supposed to have done, i.e. they might have thought that the idea was to collect these sheets and make this circuit almost by rote, but other students, I think, have actually found using the system to be a guide and an empowering, if you like...an empowering tool. And I think...to be honest with you I think it's that...it's the other percentage that I was talking to you about that the people that...if you like have lost the emphasis...that have got the emphasis...mentally have got the emphasis on the wrong aspect of the project. But it's for that reason that I would probably be doing some of my own teaching inputs in a different way to address that. So it might just be the way that I have delivered it that's caused that.

Question 6: So, moving on now, what are your feelings about the use of this software?

Response: From a teacher's point of view, I have enjoyed using the software. I think it...I think it actually has enabled me to raise the profile of electronics as an actual topic. It's allowed me to tap into the student's actual experience in this school, the very fact that they are used to using computers a lot, so it seems normal and it seems like an every day occurance. I've enjoyed...I've personally enjoyed the way that the program enables choice in a structured way, which is really good. I really think that that's an excellent idea. I enjoyed the fact that the circuit itself is very well presented and very, very clear...and various cards...that fact that you can get quite a lot from it, which again I think is excellent as the students can get a handle on...quite often a very valuable sheet was rather than having to read, for instance, a circuit diagram they had got the schematic sort of...where the components are and they can look at it and make a direct link between that and their real thing they had got in front of them. That was a powerful tool, especially with some of the students that used it.

Probe: You mentioned before that you felt it kind of changed your pedagogy; it changed the way that you taught that sort of project. Would you like to talk some more about that?

Response: Yes, as I say, probably in the past, particularly when I've been using a similar type of circuit when it was to do with the SATs project...we did actually when it came to SATs the student...the real ones...the students' did actually use the similar circuitry, the SCR circuit, and I am used...therefore I was used to...when we were doing the pre- SATs project, to actually prime them up for that, I was used to delivering a of set batch of skills and knowledge within a certain time scale and testing the students' knowledge on that in quite a formalised, teacher led form. Therefore, I would contrast it with this particular way I've been teaching this time. It was very much in terms of getting through the design process...design problem, etc, etc, and then using this program to support and guide the students in their choices. So in other words there was much less teacher, purely teacher led input. It was much more a case of...you know, I don't want to use the phrase...maybe the teacher as the enabler if you like, but I was the person that would organise the materials and the circuitry and components and so on and so forth and the students would be making decisions, even the ones...even the students that I

mentioned that might be in the percentage that hadn't really fully got a handle on the actual work that they had been doing. Even those students were in charge of, to a large degree, their own learning and were making decisions...inevitably they had to make decisions to work their way through the program. So they were making decisions based on an understanding, whether it was a full understanding or not I don't know, but an understanding certainly. They made a decision about - yes I want one that if the wire breaks the alarm goes off - yes I want one that involves the use of the varying light for my circuit to operate. So they were making decisions, even the ones that were in the percentage that had a lesser understanding.

Probe: Do you feel that there's any way that you. Let me rephrase this. You said that next time you might want to do more teacher led input. Do you feel it's possible to do that with the program or is it that the program kind of takes over?

Response: The problem would be for certain teachers, particularly if they were in a stressed environment or whatever, would be to abdicate their personal responsibility for their charges and just let them get on with it. You know it's almost...it could be used as a sort of, you know, "open book at page 19 and get on with it". It could be...I mean some people could use it like that which obviously wouldn't be...

Probe: Do you feel as though it pushed you into that way of teaching or ...

Response: I'm not saying that I did that.

Probe: No of course not. I mean do you feel that the program was taking control away from you?

Response: No...I mean what you do have to be aware of is that because the program, and the childrens' interaction with it, is throwing up sort of challenges, decisions and stuff with the children that quite often they are bringing their own individual personal agendas to every single lesson and, whereas before the job may well be easier for the teacher because they are setting the agenda in terms of what's required and what's happening, the students are bringing their own little individual agendas and that for the teacher to manage is more difficult. So in the sense that it's more demanding...it is more demanding but obviously the teacher would have to look at ways of managing that. Actually gearing themselves up to cater for that. So think of it in terms of if you like losing the group to the program, you know, I think there'd be a little bit more perspective.

Probe: Considering the sort of project that the program is designed to be used for, where children are building electronic circuits and have lots of different choices, did you find using it to be a constrictive thing, or did you find it to be a supportive thing?

Response: Supportive undoubtedly. We've...I mean there are obviously various variations that could... in terms of electronics programs for the computer. You can imagine where you would almost have like an electronics kit and the student builds the kit on the computer and then blah, blah, blah, blah. Well obviously in that particular format, that, if you like, sort of laboratory almost... virtual laboratory type of environment with a multitude of choices would be for a lot of the students, in this school, the majority of students wouldn't be able to use it, not without...again it would become...the only way that it probably would work again if it was resorted to real ultra-teacher led stuff; spoon-fed that would be the only way that we would get it. Whereas this program, the reason why this is better is because, OK there are not that many decisions to make, however, it still gives the students real decisions to make, but not that many, and engages them in their work and doesn't lose them. So I think I think it's totally supportive.

Probe: How do you feel about the sequencing of the content in the software? Was that appropriate of did things appear at the wrong times?

Response: Yes...for instance...there...to do with the sequence, there were on occasions where

the student would wish to...if you like there'd be a problem...if there was a problem somewhere where like the student would want to get back to where they were they'd have to go right from the word go. So that was a problem, so they'd like having to be sort of log on, log off, log on, log off just to get back to where they were. So that was what I mean by there might be some confusing data there. In addition to that there was some stuff to do with...but again what I'm going to say is probably to do more with a teacher getting experience with it. On occasions there might be a mismatch in terms of where you thought a student was going to be and what they were going to have to be doing next and things like this, but I didn't really find that a problem, not really in terms of the sequence. There was a logical sequence to it...

Probe: What about this problem with occasionally getting back?

Response: That was a problem. That was definitely a problem. It would be...it would be very handy if a student could sort of drop into where they...you know, where they last visited or whatever...go back immediately to where they wanted to be without having to go through...you know...

Probe: In the case where the software has gone wrong or they've gone too far and need to come back or something like that?

Response: Yes...yes...

Probe: What about the level of the language that has been used in the program; was that appropriate to your context?

Response: ...erm...

Probe: I mean obviously it varies because you've got a broad spectrum of children.

Response: I think the level you've pitched it at is pretty good. I can't see any less...any more easier language would be more appropriate without diluting the content; I think that's fine personally. And to be honest with you, you know, if there is a problem then the teacher could do a little glossary at the beginning as a little input.

Probe: Did you find that it gave you more or less time to support the kids doing their work?

Response: Essentially, it should give you more time...it should give you more time. Again, now knowing...being more familiar with the actual program and how it works, I think I could probably manage it where it would give me more time; so yes.

Probe: It would do but you need to be very familiar with the software before...

Response: You need to be familiar with how you are going to use it. Because if you're not you would be, you know, fire-fighting all the time.

Question 7: Did you use the facility to monitor the pupils' progress?....You know, where you can log on as 'HyperTeacher'?

Response: No, I should have done but I didn't.

Probe: Was there any reason why you didn't? You didn't find it necessary at all?

Response: I could see where they was by the physical...by what was on the screen, what they had printed. So I was checking their work all the time. I mean, again it's probably familiarity. So again maybe I would do it next time. Probably would actually.

Question 8: I know we have discussed this already, but for the benefit of the tape, If available would you like to continue using this software with further groups?

Response: Oh absolutely, yes. I see it as a massive plus.

Question 9: What changes would you like to see in either the content or the structure of the software?

Response: Right, are we talking about its use with the same project?

Probe: Same project, same level of...same year group of children, is there anything that you would like to see added or taken away or in the way that it operates?

Response: Yes, to do with accessing, as I mention if there was a problem with the program or whatever, it would be useful for the student to go to the relevant card of their program interaction without having to actually...without having to go through all the various previous stages again. That would be very useful to do.

Probe: If that were to happen we would perhaps be looking at a piece of software where the guidance that the software is giving would be less. Would you feel that that would be detrimental, in as much as children would be allowed to kind of wander through it wherever they wanted to go and for however long they wanted to. Would that...

Response: That would actually alter what I was thinking about.

Probe: So, therefore, would you feel it would be an improvement if there was a greater amount of teacher control, so you could, for example, look at their progress through the program and be able to reset things for them, so that you could take them back to where they were?

Response: I don't think you'd have the time to do that. I mean maybe the option would be...what about if you were to have...if it would be possible to...because I actually think it is beneficial, keeping them on track, like the one-way valve if you like, and that is useful, what you've just said...but would it be possible, as a sort of , like a live...more live sort of, if you like, diagnostic version, like a little toolkit version to be in the program whereby students don't actually use that usually, but say like for instance we had like one student who like for whatever reason had some kind of problem then it would be beneficial to sort of whiz through in a kind of more open way, in a more lab sort of type version to actually reinforce bits. In other words the teacher might be able to...you might have a very, sort of, zippy, linear version, or you might even have something whereby you...the teacher might actually be able to manipulate things in real time on screen just to reemphasise a point. That might be useful...I think that would be very useful actually, particularly for schools that have got the overhead projector for the Mac and stuff; that would be very good.

Question 10: If available would you like to use software of this particular type in other design and technology projects?

Response: Yes...absolutely...

Probe: Including projects not necessarily involving electronics?

Response: Oh I see...erm...yes I think so...

Probe: But from your reticence you obviously see less of a use for it, particularly in resistant materials?

Response: No, no, I think...I think it would be interesting to have differentiated versions of it if that was the case and choice limitation etc. In other words you've almost got the idea of virtual jigs and virtual...partially made material work, partially made projects, so you've got that concept to sort of work in. I could see that working OK, or even in terms of the

construction business, how that works, etc.

Question 11: Have you used any other educational software?

Response: Yes...

Probe: What sort of things have you used?

Response: Do you mean just programs or sort of supportive type of stuff?

Probe: Well educational software.

Response: We've got that one that we worked on with [Middlesex University student's name] we've got some of the software that we used with him; the mechanisms. That was that...we've got CD ROMS...'How it Works' and that sort of stuff.

Probe: Concentrating on say like 'How it Works', what are your opinions of it?

Response: I prefer the stuff that we worked on with [Middlesex University students name] to be honest. It was more direct...less...less...

Probe: More appropriate to the context perhaps?

Response: Well because it originated in the school, you know, we know exactly what to do to support the students' learning for GCSE and whatever. They are points that are important. So I think where it might not have the Dorling Kindersley sort of house style or whatever, what we've got is something that we think is quite good.

Probe: Have you used any other educational software?

Response: We've got...we've just got some software to do...we haven't used it yet, but it's,I can't remember, design interface, the Design Council,but that's about it really.

Question 12: Is there any educational software available that you would like to use?

Response: I understand that Middlesex has developed one, it was at the...at that exhibition. I've been told that it exists. I presume that it's something that's been worked on by the students working at [Middlesex University Campus].

Probe: Are we talking about the design and technology CD ROM?

Response: Yes, though I've not seen it. I would like to have a look at that.

Question 13: OK, that's really the interview over, but do you have any further comments?

Response: We'd certainly like to be involved in any further developments with similar software and be part of any trial that you might want to do and any further input from me I'd be glad to do. But yes, we've enjoyed using it, it was good.

29 Minutes

End of Trial 1 Interview

School C, Teacher B

Question 1: Have you taught electronics to this age group before?

Response: Yes, last year I taught year 9 and they were...it wasn't the same group and we did an astable multivibrator circuit which they used with acrylic as the other material.

Probe: So what was the product that they were producing?

Response: It was a warning device, or light, or fashion accessory thing.

Question 2: Have you taught electronics to any other age group?

Response: Year 8 and year 7 do a star, a simple circuit with an LED in it.

Question 3: So considering any of those projects really, but particularly at year 9, do you feel that these projects have enabled pupils to either design a circuit, or to select components that go into their circuit or to take any decisions about the electronics?

Response: I wouldn't say that it gave them the information to design a circuit. They know what the components do and how to put them together, but wouldn't really know how to change it to make it do something different.

Question 4: In general, how would you rate your own confidence and ability to teach electronics as part of design and technology at this level?

Response: Growing rather than confident. It's, as you know, only my second year in teaching and I...everything that I have learnt has been from you.

Question 5: What are your perceptions of how your class responded to using the software?

Response: They loved it.

Probe: So would you say that their motivation was high?

Response: Yes fairly high. They liked being on the computers but some of them found that doing anything else was an uphill struggle in the end, because I was trying to set it out rather like the projects that we normally do with a start and the research and working through and I found that quite difficult because, because the software did have the ability to do quite a lot of that, but it was difficult to record it on paper; what they were doing. I mean for them to have some evidence of what they had done. And also another thing in so far as I needed to get them working on something while some of them were putting their circuits together. Because of the nature of the group, I couldn't have them all working on circuits. They were what can only be described as a loony group.

Probe: So how was their work rate in general whilst using the software; did it compare favourably to another project or did it take longer to actually complete the project?

Response: I found it more difficult.

Probe: For any particular reason?

Response: Because of the dynamics of the group. They were...I started off with a very small group that I thought I could manage, because although I knew they were badly behaved, it was small. But because they were a small group everybody that came into the school, we have quite a high turnover of students, was put into that group. So I had coming in, sort of almost a

weekly intervals, students who hadn't done electronics before who didn't know where to start and quite a number of them had been slung out from other schools, so had behaviour problems as well and so that was difficult to manage, but probably no more difficult than running any other project, its not the software that was at fault.

Probe: You've said that the children were well motivated, but were they engaged in the project?

Response: They liked the work on the computers, but that didn't take very much time and so while I was, as I said before, while I was getting them through making, which I did sort of 3 or 4 at a time, I needed to keep the others busy with writing something or producing something to keep them on task.

Probe: So in your opinion, were they more motivated towards the work on the computer or the work away from the computer?

Response: Oh, on the computer.

Probe: What about the success rate in the project, compared to the normal situation?

Response: Yes I think nearly everybody made a circuit that had been there from the beginning and the... some of the outcomes didn't work, but I think that was bad soldering and things like that. And in the end I cut the project on the actual circuit short at the end of term and now we're making...we are working on a box for it, which we are vacuum forming.

Probe: Overall, do you think that they found it empowering or confusing using the software, or neither?

Response: Empowering I think...

Probe: You have a large number of computers within the department fortunately, but did you find any problem with the number of computers that you had?

Response: Some of them didn't work all of the time and they got incredibly frustrated with that. And in the end, what I found was that some of the revisits didn't work properly. So if they needed to revisit I just got them trawling in from the front and starting again, because the visits aren't very long, especially if you know what you've done and you just plonk your way through it and I found that sort of got rid of the frustration of it.

Question 5: What are your feelings about the use of this software?

Response: I liked it. I don't think the students used as much of it as there was because they wanted to get it finished. They wanted to find out what they needed to know, desperately needed to know, but they didn't really delve in too deeply when it was about finding out about how you made the...how a reed switch works or there's....and I didn't encourage them to print them off because our head of department was worried about the use of ink, because I think they use up quite a lot of ink with all the dark tone in them.

Probe: So do you feel that they perhaps took the quickest route through the software that they could?

Response: Yes, on the whole they did. They didn't explore.

Probe: But they were...If we go back to an earlier question you said that they were very motivated to use the software, probably more motivated than doing the other aspects of the work.

Response: I think they just liked the noises. I mean to some extent it might be as basic as that.

The fact that it recognised them and...occasionally...no actually most of the time it did recognise them. So it was like a game for them. I'm not...I don't know whether they saw it...I think they saw it as a game rather than an educational exercise, so...

Probe: Do you think that's a positive or a negative thing?

Response: Well I think that they think it's a positive thing.

Probe: What about you?

Response: I think if I did the project again I would encourage them to explore a bit more, but the first time you do anything you're really trying to complete it rather than find out every other bit and I think also this group, I only have one hour a week, so we didn't get as much done as we could have done.

Probe: Do you feel it gave you more or less control over the teaching situation?

Response: Less...

Probe: Less control?

Response: Well I did seem to spend a lot of time trying to find out who was on which computer and...luckily I had a free lesson before the...so I used to make lists of where everybody was, because I knew that If anybody was frustrated for any moment, the whole lesson could just blow up into, you know, or fall apart.

Probe: So they were using computers in the central computing area?

Response: Yes.

Probe: Do you feel the situation might have changed if the computers had been in the workshop that you were working in?

Response: Well they were, because I was in the room next to them so you didn't have to walk, you know, into another room. That was fortunate.

Probe: So to continue in that vein, did you find using the software was constrictive or supportive to you as a teacher?

Response: I think it was supportive.

Probe: In any ways at all that you could call to mind?

Response: Well...I think...I think it actually gives the students the idea that they are designing a circuit. They are sort of but they are all pretty much the same, aren't they? So in some ways it's a bit of a con. But I don't think they really noticed...I don't think they even noticed that all the printouts were pretty much the same, you know, the first ones.

Probe: Do you think that it's an appropriate con considering that that's the level that they are working at?

Response: Yes, yes I do, I do.

Probe: What about the sequencing of the content in the software; did things appear at the right times when we look at the project as a whole?

Response: Yes I think...I have a feeling that [other teacher in trial] actually got them to do it all at once, where I tried to get them to do it in sequence, but I don't know where it actually...I

mean I think obviously the circuit and then they go away and make the board and then come back to it is good, but then right at the end you kind of need all the other information together don't you?

Probe: What do you mean by all of the other information?

Response: You need the information about where all of the components go. They all come in...you need those together.

Probe: So you'd prefer them in one chunk rather than in three separate visits.

Response: Yes, because what I did was I got them to do that and then I got the printouts stuck down on a sheet, so that they had a...they had a sequential drawing of the way they went and then I got them to work from the sequential drawing, because I was unable to set up the situation where they could come and go and work through the...

Probe: Why couldn't you set up that situation; is it down to the behaviour of the group?

Response: Because of the behaviour of the group, yes.

Probe: Do you feel that that would be possible with differently behaved groups?

Response: Yes...

Probe: Would that be a situation that you would want to try or not?

Response: I would if I had a strong group, yes...even if I had a normal group, you know, it would be much easier to do.

Probe: So then it would be a supportive experience with the appropriate group?

Response: Yes.

Probe: Did you find that it changed your pedagogy at all; did it change the way that you taught?

Response: Well I haven't taught that project before.

Probe: Well sorry, to rephrase the question, you delivered say any kind of design and technology project?

Response: I don't know whether I've got enough experience to answer that, because every time I have done something it's been different.

Probe: Did you personally find the use of the software to be empowering or confusing?

Response: No I thought it was...I thought it made it seem very straightforward and I like the way that they had a review so that they remembered what they did the week before and I liked the noises too. Yes I thought it was good, it was good.

Probe: Did you find that it gave you more time or less time to support the pupils in the work that they were doing?

Response: I think if I had had a normal group it would have given me more time but I couldn't...I felt that I had to be with the group in the CAD room and meanwhile there was chaos breaking out in the other room. I mean it was just next door but it was difficult to manage. It ....I think most other kids would be fine left to their own devices and you could walk from one to the other, but...I blame the group.

Question 7: Did you use the facility to monitor the pupils progress with the program?

Response: Yes.

Probe: Was it useful information?

Response: Yes, I like...it was important to know who was doing what so that I could get the...because I was only doing about four students at once, so I could get their bits and pieces organised and it meant that I didn't have to keep a tab on it while they were working, I could go to it the lesson before their lesson and find out what they needed, where they had got to and whether...you know, how they had done the week before. That was good.

Probe: Would other information be useful?

Response: Maybe information about whether the program was working, had been working properly. Is that possible; or whether there had been a blip?

Question 8: If available would you like to continue using this particular software with further groups?

Response: Yes.

Question 9: What changes would you like to see in either the content of the software or the structure of the software?

[tape ended]

Response: No I think the content and the structure were fine. I don't think it causes any confusions at all. I don't think you need to print so much, because, for example, the first sheet...they are all the same and it think it used an incredible amount of ink.

Probe: So, for example, if the software was changed so that at the end of the visit all of the information that they needed was put onto a sheet so that they would have one print out per visit. Would that be useful?

Response: Yes, or even if they...if they didn't print the first one, but as they finished it the collected a photocopied sheet that was their's, you know, because it's the same. you could just point out to them that these are the same as the ones on the sheet.

Probe: Wouldn't that be something else to organise though; making sure that all those sheets were available?

Response: Well they could help themselves couldn't they?

Question 10: If available would you use software of this type in other design and technology projects?

Response: Yes, because the pupils really like working on computers. I'm only getting used to it. I find things like doing research on computers, which [head of department] is trying to set up, I just think it's a waste of bum seats in front of screens. You might as well give them a book. But they do like doing it.

Question 11: Have you used any other educational software?

Response: ...CD ROMs...

Probe: Which particular ones?

Response: 'How Things Work' and then there's something that one of your students did for us about mechanisms which is quite brief but it's nice.

Probe: So you still use that?

Response: Well it's on the computers and when we do a mechanisms project we show it to them, but...

Probe: What about the CD ROM that you mentioned; what are your opinions of that?

Response: I haven't used that with any groups yet but I've got it at home, because my children have got it. So I think its wonderful, you know, I think the more that students think they are playing when they are learning, the better.

Question 12: Is there any educational software available that you would like to use?

Response: My knowledge of that is pretty limited but [teachers name] is the girl, is the woman who knows about that. She's the one that is doing it next.

Question 13: So do you have any further comments?

Response: No, I just think that it's been a valuable experience for me to have done it. I just wish I had done it with a nicer group because I think I would have got a lot more out of it.

22 minutes

End of trial 1 Interview

School C, Teacher C

Question 1: Have you taught electronics before to this age group?

Response: A long time ago.

Probe: What sort of projects did you do with them?

Response: The only projects was when we had the SATs and we did... I can't remember what it was actually.

Probe: Was that the bag alarm?

Response: Erm [Teacher A] will be able to tell you, but I found it quite difficult.

Question 2: Have you taught electronics to any other age group?

Response: No.

Question 3: So concentrating on that project that you have done before, the SATs project, and you've already said that you found it quite difficult, do you feel that that project you did, in the way that you did it enabled pupils to either: design a circuit; or at least select components to go in a circuit; or in fact to take any decisions about the electronics that they were using?

Response: There was a limited choice of what else they could do and ... it was an SCR circuit.

Probe: Right so it was a similar circuit then?

Response: But most... it was pretty controlled delivery, but the fault finding was a nightmare. Because with my lack of knowledge. But with your system it made it a lot easier to find.

Question 4: How would you rate your own confidence and ability to teach electronics as part of design and technology at this level; year nine?

Response: Pretty low, but I've improved doing your system I must say.

Question 5: What are your perceptions of how your class responded to using this software?

Response: Generally they liked using the software. The problems occurred when the system on the computers crashed out and we had problems on the machines and they had to start swapping machines and then it started to go... to break down.

Probe: How do you feel about their motivation in general; was that better or worse than normal?

Response: It was good because they like using computers, you know once you get on... they could get on under their own steam... go through...

Probe: Do they generally like using computers then?

Response: Yes.

Probe: All of them?

Response: Well I would say the majority because obviously their presentation is better for

those with weak handwriting. Even the low ability group that you saw just then, they would prefer to sit on a computer and type rather than hand write, because they can then look at it, spell-check and so on that you know...

Probe: So you feel that the fact that the project made a lot of use of the software helped with motivate them?

Response: Yes.

Probe: What about their work rate during the project; was that slower than normal, or faster than normal, or about the same?

Response: I would have said that it was slightly faster at the point where they were using the computer and then going on and doing the circuit. When they were then going back to do their paperwork, then we got back to the slower pace, but if they were allowed to use the computer to present that then that sort of helped a bit and they... sort of spun that out ... work avoidance when it was difficult, for these low ability ones... but the bright kids, the other groups, the brighter ones, you know it was generally a pretty good pace. They wanted to get through it, they wanted to achieve it.

Probe: Ok so would you say that they were well engaged in the project?

Response: Yes... yes

Probe: What about the success rate that you got, I know you've been taking four groups, but the sort of general success rate...

Response: ... getting, getting the circuits working?

Probe: Yes

Response: Pretty good and even when the circuits weren't working initially we were able then to go through and sort of, sort of eliminate all the different things; looking for things which were touching and tracks which were broken and your sort of wire bridging techniques and so on and then, you know, given the push, they would go... they were reluctant to go and do that, "I can't do that", but once sort of talked through it then they saw that they could do it.They saw other people doing it, you know, and that worked quite well.

Probe: So we are talking about the fault finding part of the programme?

Response: The fault finding yes.

Probe: Do you think that your pupils, in general, found it to be an empowering situation, using the computers, or a confusing situation?

Response: They generally liked it, it empowered them because they could go under their own steam and go through, but because of the general nature of you know electronics, it's not something that they do generally, they were sort of less confident in going through and understanding things, but by the end I think that most of them have understood the basic principles of what is happening in that circuit and what the basic components are.

Probe: Now you don't really have a problem with computer numbers in the school so, in the department anyway, so I've seen their isn't a problem with the numbers, but did you find any problem with the situation of the computers?

Response: Well there is another session when I am on at the same time as [Teacher A] and then we were down to sort of four computers each, sort of thing, so it was very much of a... well, "we can only work on these". Well that was a problem right at the beginning, not being

able to work on all of them as well, sometimes because we couldn't have it all loaded up, it wasn't working right at the beginning, but generally it worked ok, apart from having to control who was going on at those times.

Question 6: So what are your own personal feelings about the use of this software?

Response: Well it certainly empowered me.

Probe: So if we asked the same question - Did you find it empowering or confusing...

Response: Yes, I found it taught me, yes.

Probe: Did you find it gave you less or more control over the, kind of, teaching situation, if you compared it to a project of a similar nature?

Response: More control because having gone through it myself, I knew what they had to look for, what were the problems that they were going to reach, both with just going through the program and knowing the 'click on this, click on that' , but also the, when you came to the fault finding, what they were having to look for and so on. So being a novice with electronics it taught me and I feel quite confident now. I know the sort of, what to look for.

Probe: And would you say that you felt more in control whilst teaching...

Response: ... oh very much...

Probe: by using the software?

Response: Yes, yes, very much. Yes that's what I didn't find in, in... that's what I explained to you, in the previous project that we had done. I was... felt completely ill-at-ease.

Probe: Did you find the use of the software constrictive for your teaching or supportive for your teaching?

Response: I think it was supportive. The restriction came when there were not enough components of the variety that was offered on the software were available at the right time, because I was being told that the students should, then having chosen them, be told, "no, well that isn't available" and I didn't... and I explained that I didn't think that was right seeing that they were being offered the choices then you were being told to stop the choice. So I then got my components! So, one might perhaps look at the ability to be able to manipulate the program so that you could set up the availability of... your own choice of availability of components that pupils could use.

Probe: Right, well we will come to a question later when we talk about changes, so if we could flag that for the time being; how did you feel about the sequencing of the content in the program; did everything seem to appear at the right sort of time?

Response: Yes, sometimes, you know, I think that the fact that you had to go through the input, the output and, you know, you couldn't get to the end, you had to keep on going through in the same sequence to get to the completed circuit. When they were trying to go back... they hadn't sort of printed something at the right time and if they had to then go back, I know there is this thing with the 'hyperTeacher', but sort of without doing that there was no facility to go, go back other than to open up a new name.

Probe: Again, perhaps we could flag that to talk about later; how did you feel about the level of language that was used in the software; was that appropriate to this particular context?

Response: Yes we all started speaking computer language.

Probe: Oh you mean by the sounds that the computer...

Response: ...,"Yes", "er, no", I mean they mimicked that but it was quite er...

Probe: What about the written information?

Response: Er yes, no I think that was pretty clear I would have... I don't think you could have made it much clearer. The students who don't have the ability to understand that level of language are just not understanding language as a whole. Like the two lads I've had just now who have very little language and you've just got to sort of point, show , and they've got to, you know, it's all this sort of miming ...

Probe: Did you notice any changes in your own pedagogy; did it change the way that you taught or did it not change the way that you taught?

Response: Generally not I don't think. I was working between, sort of, several rooms. One of the groups I have... I am in a different room so I have to send kids across so you're on a continually conveyor belt, circuit, but I'm ok with that.

Probe: But you found yourself still teaching and not having all of that taken away from you by the computer?

Response: Yes, Yes... no that was fine.

Probe: Did you find, in general, it gave you more or less time to support pupils in their work?

Response: More time, because you could... once they were set on the computer, then you could, sort of, go round and help those who needed the individual support or be in helping them make the circuit if they got that far advanced and so on.

Probe: Did you enjoy having that extra time?

Response: Yes, yes it was very useful.

Question 7: Did you use the facility to monitor pupils progress with the program?

Response: I did at the beginning but when then everything started sort of falling apart because we kept on getting the ones that were crashing out, I sort of gave up because there wasn't much point really. I mean I looked right at the beginning and saw, you know, who had done what and what components they had chosen, but I didn't end up using that to draw up my list of what components.

Question 8: If available would you like to continue using this software with further groups?

Response: Yes.

Question 9: What changes would you like to see in either the content or the structure of the software; now we have already flagged one?

Response: Yes it was perhaps one needs the ability to, sort of, manipulate the availability of components that you are willing to offer, so constrain or widen.

Probe: Would that be, that constraining of the number of components, would you see that as being a completely practical thing, as in the department only has a certain budget and, therefore, would only have certain components in stock, or would you see it as being a pedagogical thing?

Response: I think... well no, no. I think one has to do it by the stock availability and perhaps

one could do it so that there were items that they could, I mean I'm just sort of thinking off the top of my head, items that they could actually choose to physically use in their circuits, but items which they could also find out about. So it wouldn't restrict their learning knowledge but it would say right yes there are there other things but unfortunately we are only able to budget for these.

Probe: I mean do you feel that it is important that they do have that level of choice or would it be, you know, is it educationally significant that they have that choice or would it be just as well for all the children to do one thing?

Response: Oh no, they should have a choice and they should be learning, you know, sort of being able to look at different things, I mean otherwise they would never know, you know, that in the shops, which we probably talked about, that there's linking loop wire and all this sort of thing; the tremble switch, which were both choices which were only a few students made, but the fact that it was there opened up the knowledge to all of them.

Question 10: If available would you use this type of software in other design and technology projects, not necessarily just electronics?

Response: Yes, yes. Yes I mean I like interactive things. I'm in charge of the LRC and I've bought, sort of...

Probe: I'm sorry, what is the LRC?

Response: Learning Resource Centre, and I bought all of the Dorling Kindersley CD Roms and a lot of them are interactive; move about, get your knowledge, what you want and so on.

Question 11: Ok so, moving on to question 11, have you used any other educational software?

Response: Yes.

Probe: So what have you used?

Response: Well, all the Dorling Kindersley, all those encyclopaedias, we've got all those, erm what else have we got?

Probe: What are your opinions of those?

Response: It varies, it depends upon which ones. Some are quite good, quite lively, others are...

Probe: Sorry, quite good for what?

Response: Quite good in that it holds the attention and the way that they are presented is at the right level for our students.

Probe: Have you used those as part of Design and Technology?

Response: No, not a lot no, because it hasn't sort of fitted in, but...

Probe: Do you think it potentially could?

Response: It could yes, I mean sort of build it in, go off and see if you can search certain materials. The Science CD rom is quite good, but the History one, the way it sort of presents itself, is sort of... it isn't interactive enough, it hasn't got enough things going on, they love things... lots of things happening, when you click on lots of things and you've got a little movie and all those sorts of things. The history one, I don't know whether you've seen it is not

so good. You just open it and you've just got text, you know, a bank of text, whereas if it was broken up... the 'How it Works', David McCauley one, I mean the all love that. I have introduced that one to Design... they do use that over year 7 because I do the year 7 project.

Probe: So do you find that useful as part of design and technology?

Response: Yes, yes that is... so in fact, yes, we have.

Probe: But you use it purely for research?

Response: Yes, they do a mechanisms project, finding out all about mechanisms, and they then end up designing a card moving face toy. So they are then researching and just getting a basic understanding of all the mechanisms and that is very useful.

Probe: So any other educational software, perhaps just in design and technology?

Response: I did... a long time ago we purchased 'materials' but I don't know what has happened with it. I think it was 'Thames' or something; I can't remember.

Probe: Did you use that?

Response: Very little, but then again I've been sort of out in the outposts of the year 7 block. I don't know if you know about that.

Question 12: Is there any educational software available that you would like to use?

Response: I'm not aware at the moment, but I've been out of it for a bit as far as design is concerned.

Question 13: Ok that's really the interview over but do you have any further comments?

Response: The most frustrating thing was the fact that you've got this lovely system and these two computers which were throwing up the... all the faults and it even managed to get scribbling onto the front screen. I don't know how on earth they could have achieved that.

Probe: Very enterprising children! But that only happened to two of the computers.

Response: Yes two. Yes the other ones were fine it was just... there was an error at one time but that was to do with the way with how it was loaded up and that was sorted out, but it was these two particular ones which were a continuing problem.

19 MINUTES

End of trial 2 Interview

School C, Teacher A

Question 1: In considering the software what sort of task do you think it is best used to support. There are three choices here, either:

a contextual task which is very open and leaves most of the design decisions to the pupils;

a framed task which has some constraints but leaves the significant design decisions to the pupils;

or a specific task which is tightly defined?

Response: Well we can't say all of them can we? Because I think you could use it for any of them.

Probe: Right, which do you think it is best used to support?

Response: What is the actual software itself best suited to or the choice made by the teacher; what do you mean?

Probe: Well you have actually chosen to use it in a particular way, and you've used it more than once, which of those kinds of tasks, either something that is very open, something that is framed but leaves the significant choices to the pupils or something which is very tightly defined; which is...

Response: Right, framed. I did it framed. The reason being is it was something new and it... to be honest with you, I personally would... I think it would be suitable to any of those three and it would depend on the type of... for instance the group that you have just observed with [Teacher C] this afternoon, that particular group, I would actually make it a very, very specific, so that their rewards can be obvious and their immediate need for gratification can be... you know, can actually take place. Other groups I may feel I can approach in a different way. For instance the first group that I had... that I took this with, the girls group, I could probably have got, with some structure, quite an open type of frame, you know, open sort of approach to that, but it would depend on the group. I would feel that the software could lend itself to any approaches. One of those three would be particularly good. I mean it, actually like, the flow of the software you would suggest would be a framed software...

Probe: A framed task?

Response: Yes, yes. It all depends on your definition of what open ended is; is eighteen choices open ended, etc?

Probe: Do you think that a framed task is appropriate to the kind of...that stage in their development in year 9 or should it be completely open or more open than it is?

Response: No it shouldn't be more open.

Question 2: The current national curriculum divides design and technological activity into three main categories. Which of these categories have you directed most of your teaching towards when teaching this project; the three categories being:

to investigate, disassemble and evaluate products and applications:

a focussed practical task in which pupils develop and practice particular skills and knowledge;

or a design and make assignment in which pupils design and make products?

Response: The last one.

Probe: The design and make assignment.

Response: Correct.

Probe: Would you like to explain the reasons why you have directed your teaching towards that?

Response: Because in this department we try and, where possible within a given context, provide quality design and make projects to all the students. So we saw the software as an opportunity to enrich a key stage 3 project that was already going to occur anyway, so in other words it was there to enhance an electronics project in key stage 3.

Probe: And you feel it has enhanced it?

Response: Yes... I was going to say, there are still things that I need, that I would change with my own teaching approach and style with it to make it better and I will have to think about it for next year when I do it again.

Question 3 (i): In considering the national curriculum programmes of study for Key Stage 3 how well has the software performed in, firstly, allowing pupils to develop their capability in designing and making products?

Response: Oh, that's very difficult... I think... right, well, if they didn't have that then I guess their, on a very basic level in terms of actually manufacturing the PCB boards, that would be diminished. It would still be there but it would be diminished and also the... the sort of ownership factor seems to be higher with this because of the... that they feel that they have actually made something... the actual, if you like, activity on the computer is kind of analogous if you like to actually making things anyway. They actually feel that they have almost made it on the screen and then when they are making it in real life they are just if you like, not just but that's also part of it; an extension if you like. So I feel in terms of... did you say increasing the quality of...

Probe: Well allowing pupils to develop their capability in designing and making products. So really if it has allowed you to do a design and make assignment then it has it been successful?

Response: Yes, yes it has, yes.

Question 3 (ii): So again in considering those programmes of study for key stage 3, how successful has the software been in providing teaching and learning opportunities for yourself and your pupils?

Response: I would say highly successful. It has been a great motivator in addition to that. Students enjoy the feeling of being powerful with their work, there is no, you know, they can get ... they can actually... their progress, like their speed with which they can get through the work is increased. They haven't got to spend time drawing it all out or whatever. They can get the, they can actually actively engage in producing hard copy in terms of printouts and stuff and recording their progress that much quicker, which would allow potentially more diverse other teaching activities to go alongside it and to support it.

Question 3 (iii): So finally considering those programmes of study for Key Stage 3 how well has the software performed in fulfilling the specific requirements of the programme of study?

Response: ...The...er...

Probe: Concentrating particularly, for example, systems and control.

Response: I would suggest that it offers an opportunity probably which we wouldn't have taken up otherwise. So I feel it's... I actually feel it's been extremely successful in covering that and so does our IT coordinator.

Question 4 (i): Right, I'll show you this statement here as I read it out, consider that design and technology capability might be defined in terms of how autonomous pupils are in the successful derivation and completion of tasks and that a successful teaching strategy might be a process whereby pupils are gradually 'weaned' into this mode of working. How much do you agree with that statement?

Response: What in terms of don't agree, disagree...

Probe: No I mean...

Response: I, I, I... from a philosophical point of view, yes I do agree with it but...

Probe: But perhaps, not from a practical point of view?

Response: No from a practical point of view I come back to the reality of certain groups. Certain groups, say like for instance, certain groups are good groups, for instance the girls group that I had, for instance, I would guess probably 80, no more than that, I would probably say nearly 90% of them were, if you like, being able to access the curriculum and work in this kind of autonomous way and yes, yes... the boys group that I have just had, you know not that dissimilar from that, and larger, you know I had a tight reign on them to get the work done, you know, so the... you know it does... that particular programme does throw up potential for behavioural problems if you are not careful. It can also just be... it can just be a kind of a collection of paper sort of exercise if you are not too careful. You know they just want... they just want the next thing, the next thing from the printer. So you know that does need careful management. I would...as I said, philosophically I do agree with that. In practical terms I agree with it for certain students, but with other students, as I said to you before, the framework sort of model would come in and then with other groups, and with particular students, you know a specific... you know, in other words, going against that philosophy would come in, but in general where possible I would follow that.

Probe: But really we could perhaps summarise what you've said by saying that the more autonomous they are the more capable you would see them being?

Response: ...yes...

Probe: You've said that the girls group were able to work autonomously and are more capable?

Response: Yes but on the other hand certain learning styles, certain students have different learning styles. Some students don't feel comfortable with that autonomy. Some students who are equally... are potentially equally as capable, sort of intellectually, sort of there, do need, do need if you like back-up...platforms, other platforms of support.

Question 4 (ii): (Question 4(ii) not posed.)

Question 4 (iii): How successful has the software been in allowing you to pass control of the project to your pupils and allowed them to act with an appropriate level of autonomy?

Response: Probably more than any other thing I've ever done really. You know it's, it's something that when once they've learned the basics of how to do it, it's something that they are...even...the boys group even, you know, the ones that were kind of a little bit sluggish were, you know, still quite keen to get on the computer and to, you know, make their choices, so as I say it's not a, it's not a... it was interesting for me to do because it's not a style that I've

adopted in this school really. My priorities here were to, because of the nature of the fact that we have basically a 50% turnover of students from year 7 to year 11 and so on and so forth, poor attendance, dah-di-dah-di-dah, 50% free school dinners and all the associated dah-di-dah-di-dah with that, I've always felt I needed to have a strict reign on proceedings to, if you like not play to the lowest common denominator, but certainly to probably aim for pretty much the middle ground to actually achieve what I want. So in that sense it's an excellent opportunity for me to look at alternative teaching strategies to support different learning styles. So yes, you know, I'd have to be pretty sure... if it was something additional, and I don't know whether you've got other ideas about producing other bits and pieces to do with other projects, but I think it would be a good thing to do. Certainly, I am not just saying that to pander to you. I genuinely believe it to be a good thing, particularly if you've got the volume of computers.

Question 5: If the software had not been available what problems do you feel you might have encountered in delivering the same project, with the same level of choice, and hence the same level of pupil autonomy?

Response: I probably would have done... well I would have done the same project. We were going to do it but I wouldn't have had the same choice. I wouldn't have done it because the reason was it wouldn't have been, probably, I don't think the students necessarily would have got a handle on the meaning of the various options as easily. You can physically see it in action, not just as a class demonstration, like one to many, but individual attention, if you like, is given to the computer from the student. So I probably wouldn't have done it with that many options, So that's the first thing.

Probe: What sort of problems do you feel you might have if you had attempted it though with all those options?

Response: Potential chaos.

Probe: So management things really; managing the situation?

Response: Yes, yes, yes, there probably would have been... well I... it would have been... the problems would have been that the lessons would inevitably probably be a little bit drier, in the sense that you would have to have quite rigid management, classroom management techniques if you like, that kind of thing, but yes it could still be fun. It would probably still work.

Probe: Do you feel that you would have had the same amount of, kind of, spare time to go around and talk to individuals?

Response: No, no it does free up the teacher to, if you like, troubleshoot a little bit more.

Question 6: In considering your answer to the last question, has the nature of the problems that you or your pupils encountered whilst using the software to do the project changed; by introducing the computer, does it introduce different problems?

Response: No, no the only problems that have occurred have been when the program has broken down. With certain students there has been a tendency to gloss over the content, which does need to be looked, you know, the teacher needs to look at that to get a way of making the student buckle down a little bit more, maybe as I say make it a little bit more of a... more challenge, more rigorous you know. I don't mean the programme is not rigorous, but, you know, there is a tendency for people just to click on the mouse, you know, certain students do that, just collecting if you like.

Question 7: Can you think of any other contexts in which similar types of software might be valuable?

Response: When you say contexts are you talking about electronics or what, what do you mean?

Probe: Well any other context really. It could be in electronics or the other subject areas to do with design and technology.

Response: I would have thought, yes, you know, building little mechanisms things like that or structural, structures... the usual things structures, mechanisms that sort of thing.

Probe: Essentially the technical parts of design and technology?

Response: Yes, but I mean, for instance, you could do one on materials, things like that too. That's the sort of area that you could easily... you could imagine, you could look at maybe, for instance,... thinking about some exam questions, type of questions, you could think about software that could support questions to do with, for instance, manufacturing processes to do with how you would plan a manufacturing process. When I look at the component forms of that I don't know, but you could look at that. You could maybe look at simple design and make exercises too where, maybe, you've got components that can be chosen, for instance, the last, the very last D&R exam question was... the theme was, you probably know, this year was components and, in other words, the components had to be universal or interchangeable dah-di-dah-di-dah. Something like that, you know, would work, where, for instance, a little bit similar to where, if you remember, at the Design Museum they had the, they had the toothbrush designs; remember that? Something like that, I mean with a little, you know where the options... again that essentially had, in fact that did have, almost, it did have the three stage, three stages of options. You know about five for the handle, five for the middle bit and five for the end bit. You know so could have, whatever it is, fifteen different toothbrushes.

Probe: So you do see a context where it could be used, at an appropriate level, to design products?

Response: Yes, absolutely. You could even in terms... you could have it in terms of... you could do like product casings, you could do that, different shapes, textures.

Question 8: Ok, so that's the main interview questions over...

Response (earlier question): ... and the good thing about it,sorry I'll just finish there...

Probe: No, carry on.

Response: ...to do, I mean we've all seen, for instance the totally open ended software package where you have got your library of components and all the rest of it. Now that... the problem with that is of course that, It can be very useful, but it is, that is the blank page, whereas from the approach that you have used, it is an obvious structure, there is an obvious structure and it is not necessarily, some may disagree, you know, some may say that it doesn't offer them that facility for open ended learning or whatever, but inevitably you need, you do need for the level of development that the students are at, you do need that structure otherwise you, in reality you will not, you know, you won't get your result. So I suppose what I'm going to say is that definitely, you know, you could definitely see the application for that in other areas too.

Question 8: So do you have any further comments about the software?

Response: No I mean, no I think it's, I remember we've spoken before haven't we about if something happens you have to go right back to the beginning again to go through, but then you mentioned before that that was the benefit of that the students can't muck about with it, which is fair enough, you know, I think it is really good.

20 minutes

Glossary:

Courseware - The computer software used to support the design and make project.

Cognition Cluster - The stage node, the cluster of excursions, the intelligence income and the intelligence outcomes associated with the stage node.

Cluster n or **Cn** - Refers to one of the four Cognition Clusters in the courseware prototype, e.g. C2

T1 - Courseware trial one

T2 - Courseware trial two

Visit - One complete interaction with the courseware from log-in to activity node.

CV - A 'concurrent visit' where the pupil makes a visit to the courseware within five minutes of the preceding visit

SS - A 'same session' visit where the pupil makes a visit to the courseware within one hour of the preceding visit-

NS - A 'new session' visit where there is a gap of more than one hour between courseware visits

C2-CV - A strategy invoked either by pupils or teachers where users make a high number of concurrent visits to cognition cluster 2

Task Type A - A task with a particularised task entry point, "make this circuit..."

Task Type B - A task with a contextualised task entry point, "make a circuit..."

Task Type C - A task that has both particular and contextual entry point information and is based around a circuit configuration with options, "design a product that..."