UNIVERSITY
of
GLASGOW

Activity-Based CAL Design:
A theoretically-based design method for CAL materials

By

Michelle Montgomery Masters

Being a thesis submitted for the degree of Master of Science in the Department of Computing Science at the University of Glasgow.

June 2005

Table of Figures

Acknowledgements

I would like to thank a number of people for their help, guidance, and support along the way.

Thanks to Dr Tom Carey, University of Waterloo, for inviting me to work with his research group, making me feel welcome, and providing all the necessary resources to allow the first stage of my evaluations to begin.

Thanks to Dr Mark Dunlop for being the periodic sounding-block and cheerful face when work was getting me down.

Thanks to Prof Malcolm Atkinson and the REVELATION project for funding in my last year, and Stewart Macneill for patience and understanding through the last painful months.

Thanks to Dr Stephen Brewster for encouragement and support to get the corrections done!

A big thank you to Fionnuala, Liam, and Ciaran Johnson for coffee, hugs and lunchtime pick-me-ups!

Thanks to the Computing Science Department, and in particular the GIST Research Group, who gave lots of helpful ideas, feedback and advice on my research along the way.

Thanks to my Mum and Dad who set me on the right road.

Lastly, I would like to thank my husband, David Masters, who encouraged me to come back to University and study for my PhD in the first place. Thanks for all the support — financial and emotional — without you I would never have done it. Thank you for always being there.

Funding for the research reported here was provided for the first 2.5 years by the EPSRC, and for the final six months by the REVELATION project.

Declaration of Originality

The material presented in this thesis is entirely the result of my own independent research carried out in the Department of Computing Science at the University of Glasgow, under the supervision of Mr Phil Gray and Dr. Stephen Draper. Any published or unpublished material that is used by me has been given full acknowledgement in the text.

Permission to Copy

Summary

There has been more than a decade of initiatives to help promote and develop technology in Higher Education. The UK Government has funded projects such as the Computers in Teaching Initiative (CTI), and Teaching and Learning Technology Programme (TLTP), but technology in teaching and learning has still not had the impact promised for Higher Education (Geoghegan 1994). However, Sir Ron Dearing's National Committee of Enquiry into Higher Education (1997) reiterated the commitment to technology in future teaching and learning.

At the end of Phase 2 of the Teaching and Learning Technology Programme in 1996, Coopers & Lybrand; the University of London's Institute of Education; and the Tavistock Institute were jointly commissioned to carry out an evaluation of the programme so far. The report was, overall, quite critical of the results of the TLTP. The report recommended that for future development of 'courseware' there be "expertise in design, pedagogy, evaluation and management" — expertise that was not universally found in the projects evaluated. The report also found few "projects which had taken account of pedagogic issues in any systematic way." The report went as far as to say that previous research about the use of technology in Higher Education had simply been ignored.

This dissertation presents research addressing these recommendations, with the intent of enhancing future Higher Education Computer Assisted Learning (CAL) materials. This dissertation proposes that one reason for the poor quality of CAL materials, and hence their poor uptake in Higher Education, is the lack of suitable design methods to inform and guide educational software developers. Structured methods for instructional materials do exist — commonly known as Instructional Systems Design (ISD) — however, this dissertation argues that the model of the teaching and learning process implied by ISD is in conflict with current thinking in Higher Education.

This dissertation claims that:

1. A new design method based on a more appropriate model of the teaching and learning process can be created.

2. The new design method enhances the CAL design process by focussing designers on pedagogic issues.

3. Scenarios can be used to assist the development of a new design method.

In order to understand the requirements for a new design method, design as a general discipline must first be considered. The rationale and benefits of a formal method for design are also considered. Several models of the educational process are discussed in order to find a model suitable for Higher Education. It is proposed that Laurillard's Conversational Framework (1993) is both a suitable model for Higher Education, and a suitable basis for a new design method.

Reviews of existing Higher Education CAL materials, evaluated against the Conversational Framework, are presented to support the choice of educational model. Techniques from interactive systems design, commonly used for developing product designs, are described and shown to also be useful in the creation of design methods. The design method produced, called the Activity-Based CAL method or ABC method, is a major outcome of the research recorded here.

Following a series of refinements the completed design method was evaluated. Two experiments were conducted: the first experiment presented is a comparative observational study of developers given a design task to perform. One group of developers used the new method, the other used any means they felt appropriate. The second experiment was a comparative study of the new method against an existing method based on a different educational model. Again two groups of 10 subjects were used, this time the subjects were research students and research staff of a computing science department. Protocol Analysis was used on the resulting data collected from both experiments. Results of the analysis demonstrate that use of the new design method caused developers to discuss more high-level pedagogic issues rather than low-level interface and presentational issues — i.e. forcing them to consider pedagogy, which the Coopers & Lybrand report (1996) indicated was necessary for future CAL developments.

The dissertation concludes that:

1. A new design method — The ABC method — can be created based on a suitable model of the teaching and learning process for Higher Education — Laurillard's Conversational Framework.

2. The ABC method enhances the CAL design process, by focussing designers on pedagogic design issues.

3. Scenarios can be used to assist the development of a new design method

A discussion of the comments given by subjects in the evaluation questionnaire follows, which leads to a discussion of the how the ABC method could be further developed.

1 Introduction

The proper study of mankind is the science of design

Simon, 1981, p.159

1.1 Thesis Statement

A design method suitable for the development of Higher Education Computer Assisted Learning (CAL) can be created. This method can be constructed, based on a suitable model of teaching and learning in Higher Education. The resulting design method enhances the CAL design process, by focussing designers on pedagogic design issues.

1.2 Motivation

In the context of a book on Instructional Design, David R. Krathwohl in 1983 said of teaching machines and programmed learning:

> *"Education was to be revolutionised. But that has not happened. Though the tantalising promise of these ideas remains, both teaching machines and programmed instruction have yet to achieve substantial educational roles"*

Sixteen years on and the current state of play is not much different. Mayes (1995) describes this familiar cycle of anticipating the promise of a revolution in education, via the introduction of technology, and then the subsequent disappointment when it fails to deliver, as "Groundhog Day"[1]. Despite the efforts of the latest initiatives to help promote and develop technology in Higher Education — Computers in Teaching Initiative (CTI), and Teaching and Learning Technology Programme (TLTP) — Higher Education and technology still has some way to go. In October 1998, a group reviewing the CTI reported a mixed message (Utley 1998): the CTI was seen to be growing in importance as more institutions developed more formal teaching and learning strategies. However, "underuse of CAL remains a continuing major problem" for virtually all institutions. The group also reported that academic staff-development programmes were "relatively ineffective in supporting use of CAL." The group also said that many costly resources were being wasted through duplication of effort across institutions, and that there was a lack of collaboration and dialogue.

[1] This is named after the film of the same name, where the lead actor has to experience the same day over and over again.

Sir Ron Dearing's National Committee of Enquiry into Higher Education (1997) stated clearly that the future of Higher Education would still be with technology:

> *"for the majority of students, over the next ten years the delivery of some course materials and much of the organisation and communication of course arrangements will be conducted by computer."*

The Dearing Committee estimated that Higher Education in the UK spends between £800 million and £1 billion a year on what it refers to as Communications and Information Technology (C&IT), and suggests such a level of expenditure will continue. After this clear commitment to C&IT by Dearing, and the Government's Green Paper on Lifelong Learning, we must analyse more closely the reasons for the poor performance of CAL in the past.

At the end of Phase 2 of the Teaching and Learning Technology Programme in 1996, Coopers & Lybrand; the University of London's Institute of Education; and the Tavistock Institute were jointly commissioned to carry out an evaluation (1996) of the programme so far. The report was, overall, quite critical of the results of the TLTP. The report recommended for the future development of courseware that there be "expertise in design, pedagogy, evaluation and management," — expertise that was not commonly seen in the projects that the evaluation report looked at. The report also found few "projects which had taken account of pedagogic issues in any systematic way." The report went as far as to say that previous research about the use of technology in Higher Education had simply been ignored. The report stated that it was their belief that:

> *"a more serious and helpful attempt to encourage projects to engage with pedagogic issues might have :*
>
> - *saved a considerable amount of time;*
> - *avoided the reinvention of many wheels;*
> - *led to a more effective (and perhaps, efficient) use of the technology."*

This dissertation aims to address this need for more guidance on pedagogy and CAL by developing a design method for educational software developers to use.

...compared to what it should and will be, today's interactive software is wooden, obtuse, clumsy and confused. The pervasive lack of imagination and good design is appalling. (Nelson 1990)

This is, of course, a generalisation. However, this dissertation describes a review (see Chapter 3) of thirteen CAL packages, and found only one package that had any formal instructional design involved in its creation. The Coopers & Lybrand report (1996) noted that, when talking to the developers of TLTP materials, few were able to indicate the model of learning that their materials were built on, which Coopers & Lybrand considered to be important for effective materials to be developed. At MediaActive '94, Professor Alistair MacFarlane, principal of Heriot–Watt University delivered his keynote address entitled "Future Patterns of Teaching and Learning." He stated:

As we move into the next century, technology thus provides us with both a challenge and an opportunity. The challenge is to find out how to construct and deploy highly-supportive environments.

The existence of statements like these about current CAL; the underlying reasons for them; and the continued commitment to CAL's future in Higher Education has motivated the research discussed in this dissertation regarding CAL design, and the search for methods to improve future CAL developments.

1.3 What are CAL and C&IT?

At this stage it is appropriate to define the terminology used when discussing technology in education. The terms 'CAL' and 'C&IT'[2] are often used interchangeably and can refer to any or all of the following (CTI Primer, 1998):

— Lecture notes placed on the Web for students to prepare from.

— Courseware developed in-house or bought off-the-shelf.

— Email noticeboards to encourage student discussions.

— Simulation software to model real-world problems.

— "Drill-and-practice" self-assessment exercises.

[2] Sometimes also referred to as 'ICT.'

This is by no means an exhaustive list.

For clarity, definitions of CAL and C&IT will be given for this dissertation.

C&IT refers to the application of digital technologies for teaching and learning or for teaching and learning support. Thus, the application of computers to course administration and management, such as the maintenance of student records, or storage of examination results, would be C&IT. Clearly, one can make a distinction between software used as an integral part of the teaching and learning process and software used in a secondary role to support that process. In this dissertation the term CAL refers to the former role. Defined in this way CAL is a subset of C&IT.

The term 'courseware' generally refers to software specifically designed to teach all or part of a topic within a course, and is exemplified by software produced under the TLTP scheme. (See section 3.1 and Appendix 10 for descriptions and examples.) However, there is also a middle ground where the role of technology is less easy to identify. Email noticeboards, when used to encourage student discussion, may be integrated into structured learning. However, such noticeboards may well not have been designed for that educational role, and may be used for many other non-educational purposes. In that sense they can be distinguished from software like courseware or computer-based quizzes that are specifically designed to fit into an identifiable teaching and learning niche. The ABC method presented in this dissertation is concerned with CAL in the wider, and more inclusive, sense that encompasses courseware and the use of these, more generic, middle ground technologies.

1.4 Thesis Outline

This dissertation discusses the design and evaluation of the Activity-Based CAL (ABC) design method — a new structured design method for Computer Assisted Learning (CAL) materials in Higher Education. Chapter 2 starts by discussing what design is, and what it means to different design communities. The chapter then continues by describing design methods in these communities, and why a design method was used and the generalisations that can be made from these methods in other design communities, to help influence the development of the proposed design method for CAL. The chapter then focuses on design methods for instructional materials in particular. The chapter concludes by considering models of the educational process in order to find a model suitable for teaching and learning in Higher Education, and selects Laurillard's conversational framework (1993) as most suitable.

Chapter 3 discusses reviews performed on current CAL packages using the conversational framework as a review tool. The reviews highlight which categories of the conversational framework are commonly found, and indicate where a new design method could provide more support.

Chapter 4 describes the creation of the ABC design method. The chapter discusses the use of techniques from interactive systems design to aid the creation of the new method. These techniques generate requirements for the new method, which are described and refined as the development process continues. The complete design method is then discussed and described in full in Appendix 1.

Chapter 5 describes two studies performed using the new design method. The final experimental results are presented indicating the positive effect the new design method has had on the CAL design process. This chapter also discusses the use of the new method in the creation of "CAL for Firefighters" and "CAL for Oxfam", providing evidence that the method is usable by other designers.

Chapter 6 discusses the research presented in this dissertation and shows how the original claims have been satisfied. The chapter also discusses the research questions that have arisen in the course of writing the dissertation. The chapter concludes with suggestions for future work to improve and further develop the research presented.

2 Review of Design

In an effort to understand the requirements of CAL design, it is appropriate to begin by looking at design as a general discipline.

2.1 What is Design?

Holmes et al (1995) gave the following definitions for 'design':

Design:
v. to mark out: to plan, purpose, intend.
n. a plan conceived in the mind, of something to be done.
n. adaptation of means to end.

Others definitions include:

A goal directed problem solving activity (Archer, 1965).

The imaginative jump from present facts to future possibilities (Page, 1966).

A creative activity – it involves bringing into being something new and useful that has not existed previously (Reswick, 1965).

Simon (1981) describes design as a guided search for a satisfactory solution under certain constraints e.g. time, material, money. Design means different things to different communities. Design to a graphic-designer is about creating aesthetically pleasing images to create a corporate identity or produce packaging design. An industrial-designer sees design as being about the creation of the next generation of consumer products or automobiles. An architect's design is the blueprint for a new office-block or house. Design can be judged by the resulting artifact or as the process that is gone through to get to the artifact. In the context of this dissertation, CAL design is defined as a process, which produces a blueprint for the production and implementation of CAL products.

2.1.1 Design as a Craft versus Design as an Engineering Discipline

When a furniture-maker is commissioned, by a client, to create a chair, he or she will come up with an initial design, perhaps in consultation with the client. He or she will then carefully craft the chair in a suitable wood, and will then present the chair to the client. The client, on viewing the chair, thinks that the chair legs look a little too thick and requests that the furniture-maker adjusts the legs. The furniture-maker will skillfully adjust the legs. The chair is once again presented to the client. The client is happy with the legs but this time thinks he would like some additional carving on the back of the chair. The furniture-maker again goes off and makes the necessary changes, applying his experience and skill, and once again presents the chair to the client. This iterative process will continue until the client is happy with his commission. Although there are similiarities with this process and that of rapid prototyping (Murat & Yeh 1989) in software engineering, it is difficult to imagine using this unstructured approach to design for a large complex educational system, especially where time and resources are limited. This natural design process is typical of the design process that skilled artisans perform (Norman 1990). CAL design, however, is not always done by skilled or experienced people — it is often performed by lone academics trying to support a piece of their curriculum with some CAL (See section Chapter 3 for review of Higher Education CAL projects.) It is at this point that the difference between design as a craft and design as an engineering displine can be seen.

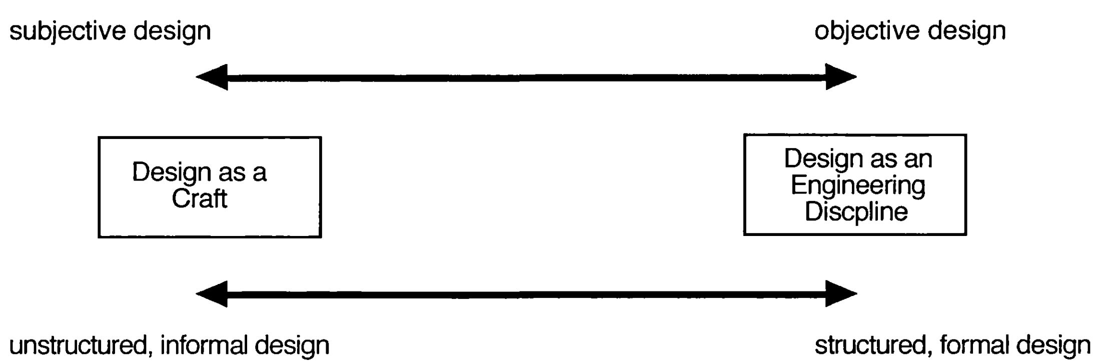


Figure 1 *Design spectrum illustrating the difference in design as a craft and as an engineering discipline.*

Design by craft is often subjective (Holmes et al 1995), as illustrated by an example from the art world: there are many different types of art produced by many different artists. Some people like abstract art, others prefer landscapes. Engineering design is more objective and often there are agreed standards for what is acceptable design. For example, in the car industry, car designers have a basic standard design that is followed: generally the car has four wheels, an engine placed at the front of the car and a steering column to control the car. It is the use of design methods in the engineering process that result in more objective engineering designs. The design method is a way of encapsulating experience and formalising knowledge that can then be utilised by less skilled or experienced designers (Reeves et al 1995). Formalising the design process in a design method makes the process more visible, more predictable, more repeatable, and consequently more cost-effective (Nielsen & Mack 1994).

Design methods also help to address problems of scale: if the furniture maker above was asked to make 100 chairs exactly the same, he or she would find it difficult to control and manage the quality of the output i.e. the chairs. With the assistance of a design method, the furniture-maker would be more likely to be able to replicate their original design. Systematic design methods are not a new invention: they date from the 15th Century in Architecture (Jones 1992, Alberti 1988). Guindon (1990) says a design method:

> *"by definition, dictates or suggests a sequence of activities to be performed, and therefore is a prime influence on the planning and control of the design process."*

2.1.1.1 Considerations for a new design method

From the review of design above there are some important factors that seem common to design methods in various design communities and which should be considered in the development of the proposed design method for CAL.

A new design method should:

- allow a designer to plan out their design.

- enable a designer to make their design more objective.

- encapsulate experience and knowledge.

- make the design process visible.

- allow a designer to control the design process.

2.1.2 Design Methods in Software Engineering

It is out of these issues of complexity and scalability, as discussed above in section 2.1.1, that the cross-discipline design methodology movement grew from in the 1950s and '60s (Goel & Pirolli 1992). There had been a number of recent large-scale engineering projects that had run into problems: c.f. the Polaris Missile project and the moon landing. The projects came in late and overbudget. The design methodology movement responded with a number of prescriptive proposals for the systematization of the design process. Until this time software design had been what Pressman (1994) calls a "seat-of-the-pants" art. General-purpose hardware was becoming more common place at this time but software was still very much at the "craft" stage — custom-written and often used by the same person that had originally designed and developed it. Off-the-shelf software packages were still some way ahead. Since the design, development and implementation of early software was done by a single individual, the design process was implicit, in the head of the designer, and often not documented. Moving from the 1960s into the 1970s, hardware became cheaper and the computer market was booming. Naturally there was a large demand for software to run on this multitude of hardware. "Software houses" popped up to write the "killer app" for the new hardware. The market for off-the-shelf software was now right (Pressman 1994). Software was less frequently written by a lone individual, and its end-user would more than likely be someone other than the original designer. The 1970s saw the emergence of the first design methods to help designers describe their ideas to others, and to control and structure the design task (Budgen 1994). One of the first such methods was the "waterfall model" (Royce 1970).

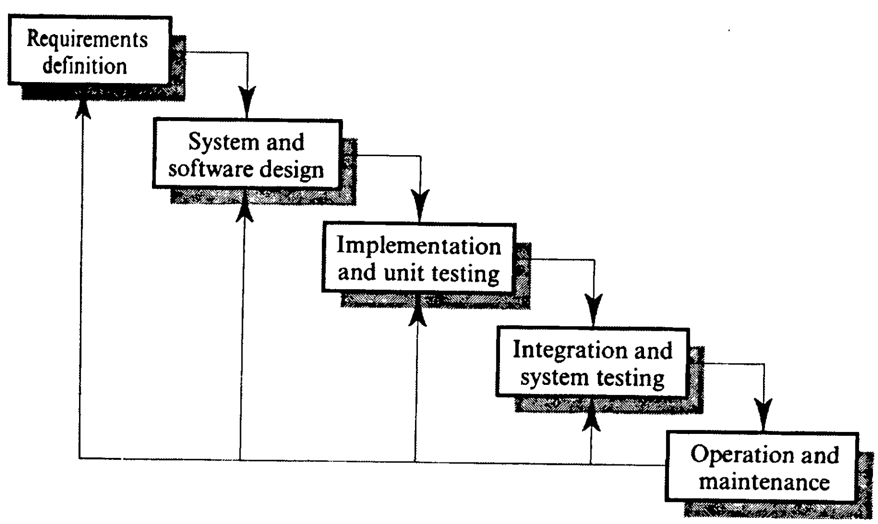


Figure 2 *The software engineering waterfall model for software development. (Royce 1970).*

This first method offered designers a systematic, sequential approach to the development of their software products, guiding them through from requirements capture to software being in use and maintained. This method worked well for some time and was influential in the new design methods of the software industry. It was not the "silver bullet" [3](Brooks,1987) that software engineering was looking for but it did make the design process visible and repeatable.

This approach to problem solving follows what Winograd and Flores (1986) called the rationalistic tradition. They describe the rationalistic approach to problems as the following:

1. *Characterise the situation in terms of identifiable objects with well defined properties.*

2. *Find general rules that apply to a situation in terms of those objects and properties.*

3. *Apply the rule logically to the situation of concern, drawing conclusions about what should be done.*

It is easy to see how the waterfall model follows these rules. Requirements definition and system/software design match with step 1. The overall model, with its sequential stages, covers step 2, and the application of these logical stages matches step 3. The waterfall model was used for the next decade but designers reported problems using it in their software projects. Designers found that real projects rarely followed the sequential stages that the model proposed (Pressman 1994): it was difficult to get all the requirements from the customer at the start of the project, and from the customer's perspective they often did not see a working version of the software until late in its development. In the same way that Winograd and Flores questioned a rationalistic tradition and its use in thinking about computers, designers questioned the waterfall model for the design of their systems.

Software Engineers developed the next generation of design models to follow more closely what they actually did when designing a new system, and to address some of the problems that were identified in use of the waterfall model. A *prototyping* model (Brooks 1975) of software design allowed customers to be more involved in the design process. This gave customers an opportunity to use the software early in the design process and evaluate if the software really did what they wanted, rather than waiting until right at the end of the design, as was the case in the waterfall model of design.

---

[3] Silver bullets were believed to be the only way to solve the problem of werewolves, i.e. kill them. Brooks discusses trying to find the silver bullet for software in 1987, i.e. the bullet that would 'kill' the problems of software engineering.

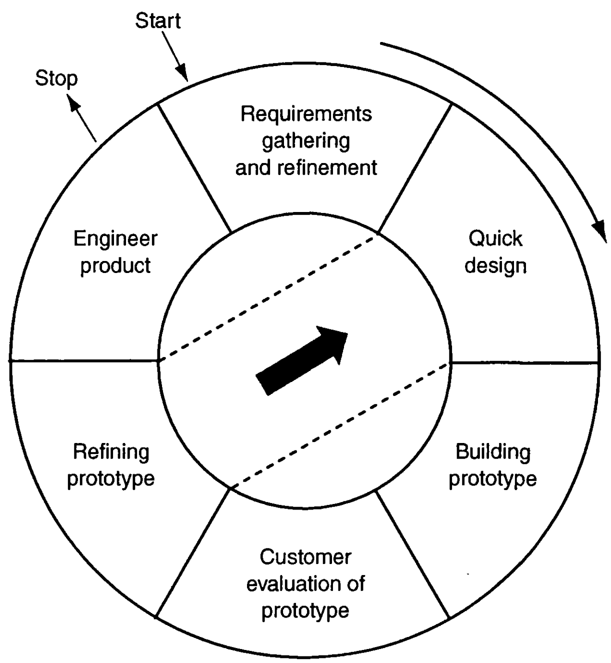


Figure 3 *The Prototyping model (Pressman 1994)*

Boehm's (1988) spiral model of software engineering combined the waterfall model and the prototyping model. It also added a new component to the software engineering design model — risk analysis. Risk analysis allowed design alternatives to be considered and to calculate the implications or risks involved in implementing them.

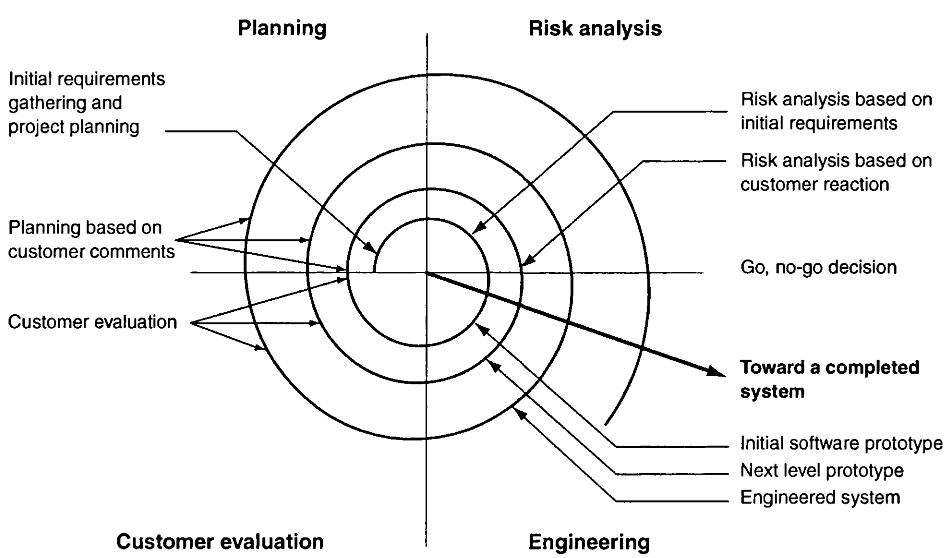


Figure 4 *The Spiral Model (Pressman 1994)*

This more objective and reflective model of software engineering follows a more onotological approach to design (Winograd & Flores 1986), where problems are solved with reference to context and not in subjective isolation by a software designer.

2.1.2.1 Considerations for a new design method

From the review of design in software engineering there are some factors which should be considered in the development of the proposed design method for CAL.

A new design method should:

- not enforce a sequential design process on a designer.

- consider the context that a new design will be used in.

2.1.3 Design methods in Human Computer Interaction (HCI)

The software engineering methods discussed above helped the designer make their design process visible and more efficient. However these design methods focussed on system functionality i.e. what the system would do. The HCI field focuses on what the user does with a system, how they interact with the system. Consequently HCI design methods are user-centred (Preece et al 1994):

> *A key aim of HCI is to make users the focus of the design activity, hence the term user-centred design. This is achieved by involving users and taking their needs into account throughout the design process (Preece 1993).*

This view of design again follows Winograd & Flores' (1986) more ontological view of design, considering the users, the system and the context it is used in, not simply the system's functionality in isolation.

One example of a user-centred design method is the Star Model (Hartson & Hix 1989):

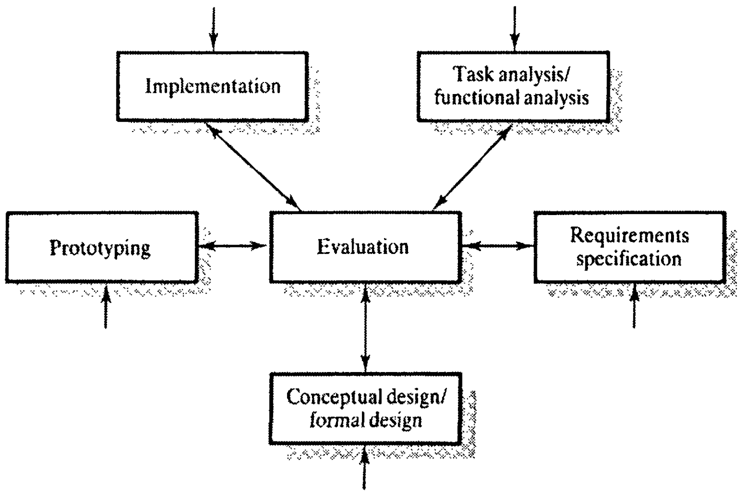


Figure 5 *The Star model an example of user-centred design method in HCI. (Hartson & Hix, 1989).*

With evaluation placed at the centre of the model, all other aspects are thus subject to evaluation. This model also does not place any logical ordering or sequencing on the different sections of the model, this contrasts with the waterfall model as discussed in Section 2.1.2. The user is involved in every aspect of the design process. Other HCI user-centred design techniques can be utilised to help support different aspects of the star model design process e.g. to enable users to be part of the complete design process, they need to be able to understand the language of designers or understand the documentation the designers have produced. These documents are often difficult for users to comprehend and can therefore exclude the users from the design process. QOC notation (Questions, Options, Criteria) developed by MacLean et al (1991) allows designers and users to work together and explore design decisions. QOC helps designers by forcing them to discuss explicitly the advantages and disadvantages of a particular decision. QOC helps the user to participate in the design discussions. This approach to design leads to a more reflected, considered design that hopefully leads to a more useable end system. The advantages and disadvantages of a design decision are explored by creating a QOC diagram:

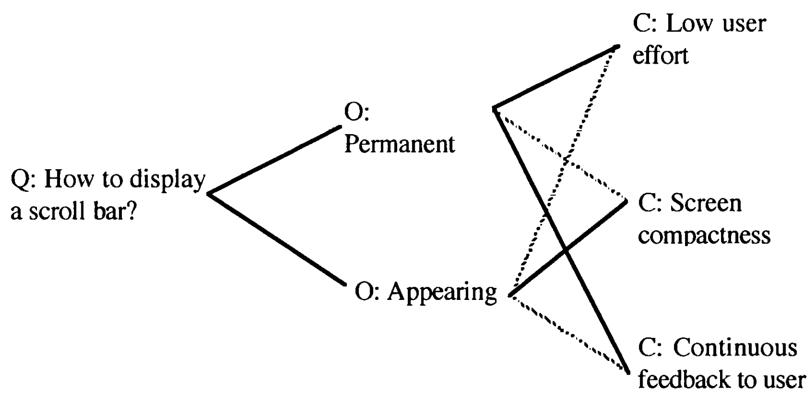


Figure 6 *An example QOC diagram (MacLean* et al. *1991)*

This diagram shows the questions, options and criteria considered by some designers when deciding how a scroll bar should be displayed in a window. The designers have decided on two options, either the scroll bar is displayed permanently or it appears whenever the user moves the cursor over a certain area on the screen. The designers have also identified three different criteria to help them choose between alternatives: low user effort; screen compactness; and continuous feedback to user. In the diagram, solid lines represent positive relationships between the option and criteria and dashed lines indicate negative relationships. So, displaying the scroll bar permanently is good for user effort and feedback, but not for screen compactness. Having considered all the options, designers and users can settle on one of the options.

2.1.3.1 Considerations for a new design method

From the review of HCI design above there are some factors which should be considered in the development of the proposed design method for CAL.

A new design method should:

- consider the user of the system and their needs in the entire design process.

- enable a designer to consider and explore their design decisions.

2.1.4 Design Methods in CAL

Realising the problems of bad design, overbudget projects, software delivered late etc., software engineering addressed its crisis by developing techniques and methods to apply to the software process. These methods were accepted by the industry as a way to make the development and design process visible, and hence able to address the cost and quality issues. Harrison (1994) says that CAL should be concerned about the same issues:

> *"...it is concerned with a systematic approach to the planning and delivery of the educational experience... From good design it should become clear how to best deliver a quality learning experience."*

The United States involvement in the Second World War (WWII) is held responsible for the fast growth in the popularity of instructional design (Leigh 1987, Wiburg 1995). Instructional Design or Instructional Systems Design (ISD) is the name given to design methods in CAL and is defined as:

> *"The systemic and systematic application of strategies and techniques derived from behaviour and physical sciences concepts and other knowledge to the solution of instructional problems." Anglin 1991*

With the advent of WWII there was a demand for the rapid training of hundreds of thousands of military personnel. In the 1920s and '30s a number of people (Tyler 1975, Thorndike 1921) had made the connection between educational outcomes and planned instruction, specifying desirable outcomes and then planning instructional activities that would result in these desired outcomes. This approach to instructional design is illustrated below.

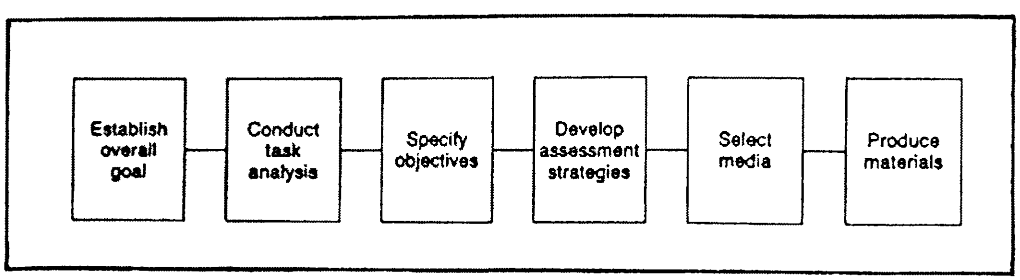


Figure 7 Early model of instructional design. (Anglin 1991).

Following this early systematic instructional design method, the military was able to produce training materials in large quantities. Similiarities can be made with this early model of the ISD and the early software engineering models, the waterfall model (as discussed in section 2.1.2): it follows the same rationalistic approach (Winograd & Flores, 1986), decomposing the problems into logical steps, and applying these steps sequentially. Designers in both communities were trying to make the design process systematic, visible and replicable to address the problems of scale and complexity faced. As in software engineering, instructional designers did not find this initial model perfect — it did not follow exactly what they did in practice since the sequential logical steps were too constraining. New models of ISD were developed which allowed the output of each step of the ISD process to be fed back into the early steps, and influence the design as necessary. Evaluation stages were also added, recognising the need to continuously evaluate a design.

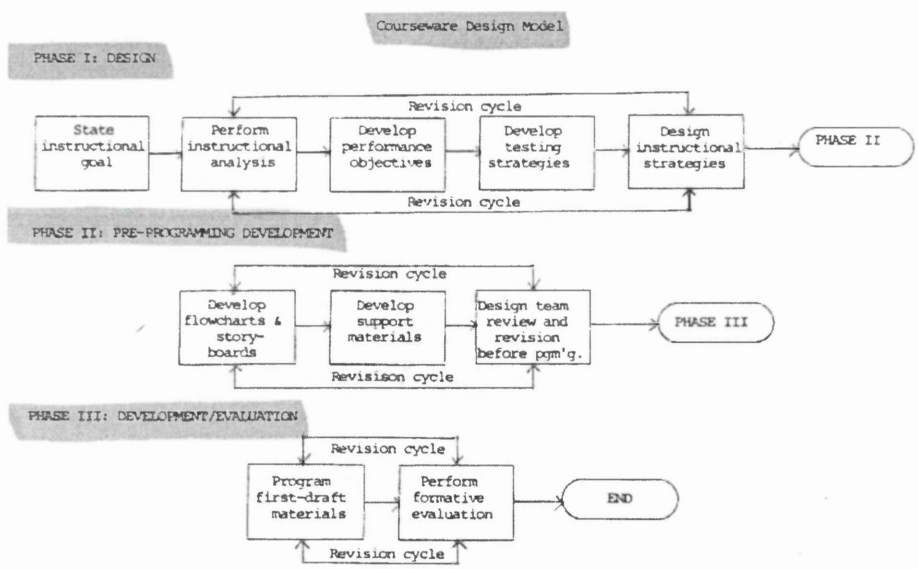


Figure 8 *Revised ISD model that incorporated feedback and evaluation in the process. (Jonassen 1998).*

During the 1970s and '80s more ISD models were created (Gagne & Briggs 1974, Dick & Carey 1990) which coincided with a resurgance in using computers in teaching and learning. Tripp & Bichelmeyer (1990) combined the ISD models with software engineering and proposed Rapid Prototyping as an alternative instructional design approach. Although ISD has been reported to be effective for the design of instructional materials (Branson & Grow 1987, Briggs 1977) it has been admitted that this approach to design is costly:

"...when one is venturing into instructional design, which is quite expensive, one should justify the cost." Romiszowski 1981.

Bednar et al (1991) propose that:

"Instructional design and development must be based upon some theory of learning and/or cognition; effective design is possible only if the developer has reflexive awareness of the theoretical basis underlying the design."

ISD grew up as a by-product of Programmed Instruction, which was based on the Behaviourist theories of teaching and learning developed by Skinner (1954). The psychologists believed that application of behaviouristic learning principles would "make instruction and education more systematic, controllable and effective." (Lowyck & Elen 1992) The underlying idea behind Behaviourism is that it is pointless to theorise about the inner workings of the brain since we are only able to study the behaviour of people in response to stimuli (Skinner 1954). Changes in behavior are the result of an individual's response to events (stimuli) that occur in the environment. When a particular Stimulus-Response (S-R) pattern is reinforced (rewarded), the individual is conditioned to respond. Teaching and Learning based on the Behaviourist traditions has an emphasis on teaching strategies, such as repetition, that encourage rote-learning rather than promoting higher-order cognitive processes. Programmed learning grew rapidly in the military since the behaviourist model of teaching and learning suited the type of learning that often occurred in the military setting e.g. rote-learning of how to assemble weapons. The first instructional design models were built on the early work of Gagne (1962) who developed his "Conditions of Learning" with special attention to military training settings. The focus of behaviourists is on the output of the learning process, i.e. observable changes in the behaviour of the learner (Ibid). This approach implies that teaching causes learning directly, that each piece of the package can achieve one of the learning objectives. This view is not widely supported by the education community (Maturana & Varela 1987, Winn 1989), or even instructional designers when questioned. I propose that one of the reasons for ISD methods not being taken up widely in Higher Education is that education has disagreed with the educational model behind such methods. Behaviourist psychology is linked to the educational theory known as Instructivism or Objectivism (Jonassen 1989), this is explored further in the section below.

2.1.4.1 Considerations for a new design method

From the review of design in CAL above there is a factor which should be considered in the development of the proposed design method for CAL.

A new design method should:

- be based on a teaching and learning theory.

2.2 Educational Models

In seeking to improve educational design methods, we shall consider alternative educational models on which they might be based. Instructivism is considered first, the implicit model of teaching and learning in ISD. Two other models of teaching and learning that are well respected in Higher Education today — Constructivism and Laurillard's Conversational Framework — are also discussed.

2.2.1 Instructivism

Followers of Instructivism believe that knowledge is an objective reality, external to the learner, which can be transmitted from the teacher. A German parable offers the metaphor of the Nürnberg funnel: "a magical philosopher's funnel inserted into the head of a boy, used to pour knowledge directly into the head." (Draper 1994)

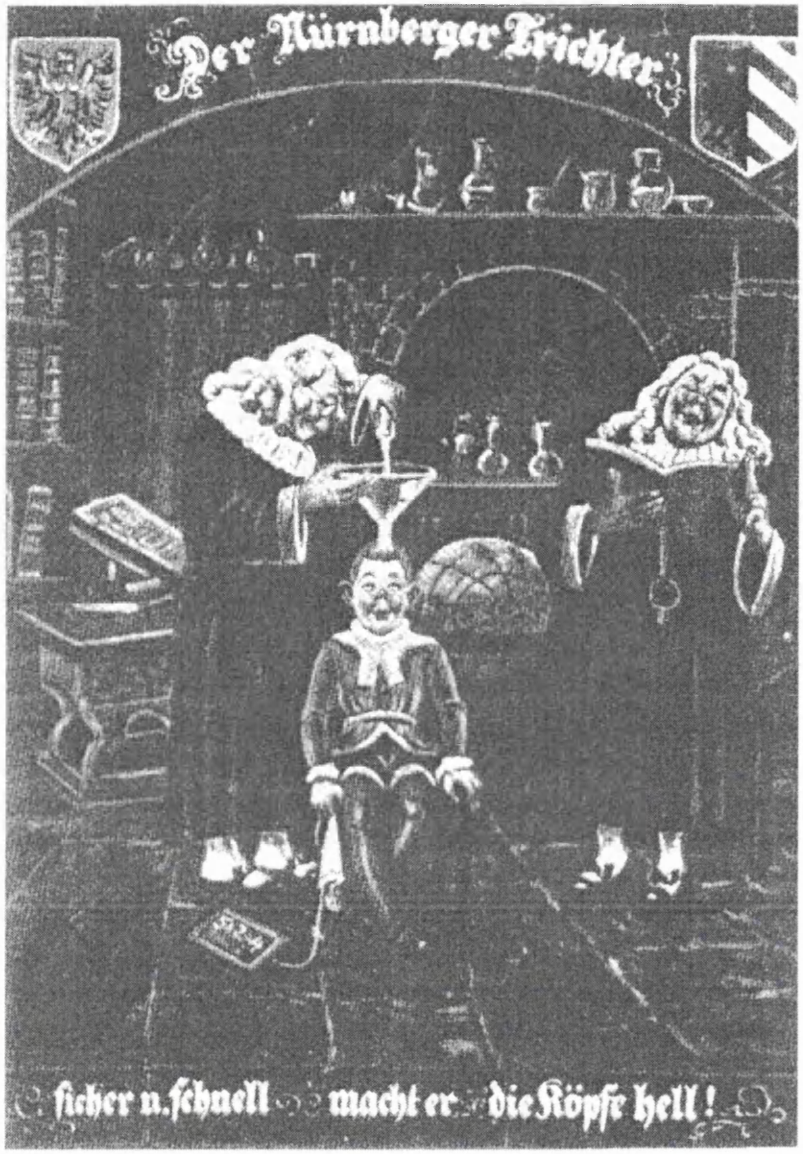


Figure 9 Nürnberg Funnel, Reproduced from "The Nürnberg Funnel" by John M. Carroll.

The role of instructional design in the instructivist world is seen to make "knowledge transmission" more efficient (Jonassen 1989). The purpose of teaching based upon instructivist principles is for the learner to accept and then be able to replicate the objective reality that the teacher delivers. In this way Instructivism is very teacher centred, with no room for the learner to form their own interpretation of the knowledge or relate it to their personal experience. These ideas link with the behaviourists traditions that underpin ISD:

> *"Designers use their objective tools (e.g. task analysis) to determine an objective reality which they can then try to map onto learners through embedding instructional strategies that control learning behaviour." Jonassen 1989.*

2.2.1.1 Instructivism in CAL

Instructivist principles suited the type of teaching and learning often delivered by early CAL programmed learning machines found in the military: there, students were often required to learn by heart, factual, objective details about weapons, machines or military procedures. CAL designed following the instructivist principles lent itself to this rote-learning by delivering "drill-and-practice" exercises to students. Typically the content of such CAL materials is broken down into small sections with assessments at the end of each section to reinforce material and offer remedial materials for the user. This type of teaching and learning is still used today in some sections of Higher Education — learning foreign language vocabulary is one such example. A recent CAL example built around these principles is "French Word Torture" (Rice 1989), a French language tutor which sets translation exercises.

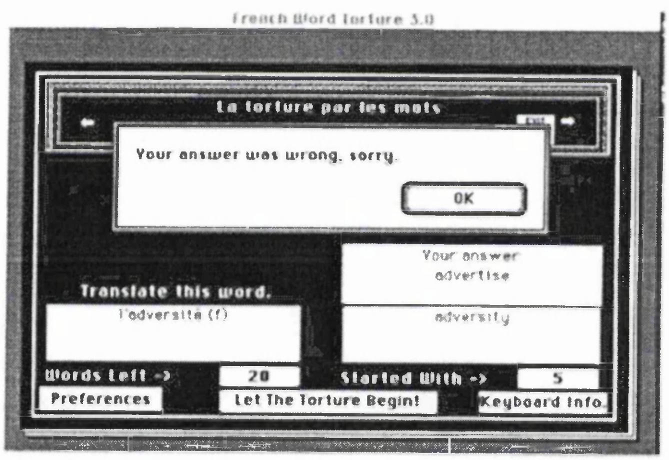


Figure 10 Screenshot from "French Word Torture" produced by HyperGlot.

The CAL program displays French phrases that the student must try to translate. Once the translation is entered the CAL program will give feedback on the answer given. The student is able to repeat these exercises over and over until they feel confident with the new vocabulary.

2.2.2 Constructivism

Constructivism is often seen as the antithesis of Instructivism. Radical constructivists believe that there is no objective reality that learners strive to attain, instead each learner constructs their own reality based on their individual prior mental contents and current input. This model of the teaching and learning process is learner centred, although the teacher has a role in providing input to the learner. Taken to extremes, Constructivism argues that there is no common knowledge to be attained, knowledge is individualistic and that the role of a teacher is not to transmit an objective reality to a learner, as in Instructivism, but to help learners construct their interpretations and representations of the reality. Draper (1994) notes that Constructivism warns us that teaching cannot be taken as the sole or even main cause of learning, since there are other inputs and influences to the learning process.

Constructivism grew from the work of Bruner (1966) who argues that learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. Much of Bruner's work was linked to child development research, particularly the work of Piaget (1970). Piaget called his child development theory "genetic epistemology" since he was mainly interested in how knowledge developed in humans; Piaget also believed that learning was an active process, which adapted according to the environment. Piaget believed that children developed by creating "cognitive structures" which represented physical and mental actions that underlie specific acts of intelligence e.g. sucking in the early stages of development, or recognising shapes later on. Through, what Piaget called "adaption, assimilation and accomodation," these cognitive structures change as the child develops and new learning takes place. Bruner's work was based on these fundamental ideas — knowledge was constructed and learning adapted, based on what a student already knows.

Although there is agreement on the basic foundations of Constructivism by educators (learning is active, knowledge is contructed etc.) there is no such general agreement on how to implement these fundamentals in a teaching and learning situation. Some believe control of the learning should be left completely to the learner, others believe there should be an element of teacher control. Moshman (1982) attempts to differentiate these sub-groups of Constructivism by subdividing Constructivism into three subforms — Endogenous, Exogenous and Dialectic Constructivism. He defined these subdivisions as follows:

> ***Endogenous constructivism*** *— emphasises the learner's knowledge construction process and the role of the teacher as a facilitator of this construction process.*
>
> ***Exogenous constructivism*** *— focuses on formal instruction that learners can reflect on and transfer to future situations and experiences. The learner should be able to control and direct the instruction to some extent.*

Dialectic constructivism *– focuses on putting the learner in a realistic learning situation that they can interact with and the teacher providing scaffolding or support for the learner in these situations.*

Dalgarno (1996) illustrated the different Constructivist viewpoints with the following diagram:

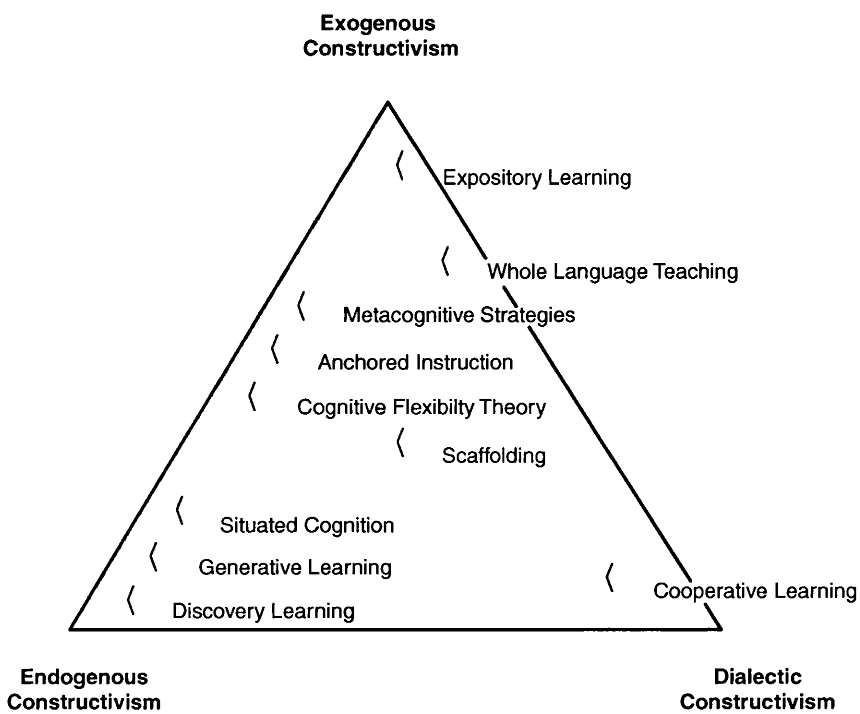


Figure 11 Constructivist viewpoints. Reproduced from Dalgarno, B. Constructivist Computer Assisted Learning: Theory and Techniques. In proceedings of ASCILITE '96.

2.2.2.1 Constructivism in CAL

Hypertext and hypermedia CAL materials, available for example on the web, would be typical of endogenous constructivism where it is up to the learner to explore a learning resource that the teacher has produced for them, and to construct their knowledge of a topic based on their exploration. Illustrated below is as online self-paced tutorial to learn the Java programming language. Learners are free to follow any of the hyperlinks to different subtopics and perform exercises to test their knowledge so far, no teacher instruction is given.

Figure 12   Online Java Tutorial. http://www.sun.com

CAL materials that have elements of learner control, and adaptation to learner needs, would be examples of exogenous constructivism. This is illustrated below in a screenshot from a Dental CAL package. The learner has attempted a quiz to test their knowledge of the subject so far. The student has answered the question incorrectly. This CAL package, based on the response the student gives, takes the student back to the relevant section of the original material for review and revision.

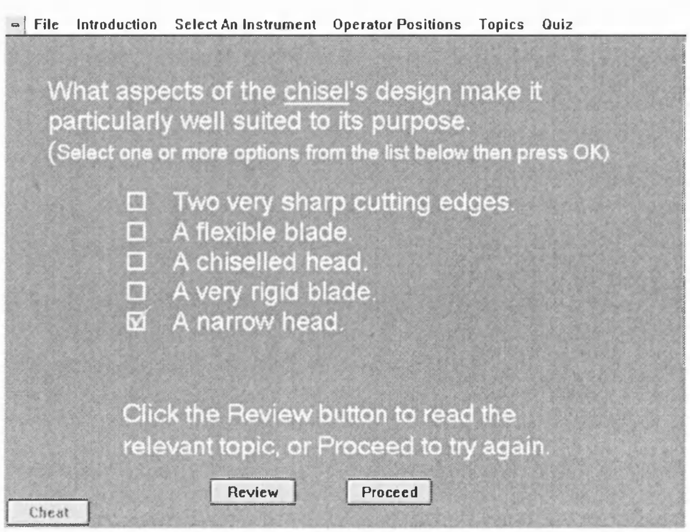


Figure 13   Dental CAL screenshot from "Sharpening Dental Instruments".

Dialectic constructivism can be seen in CAL systems that allow collaboration and provide support systems for the learner. These are commonly referred to as Computer Supported Collaborative Learning (CSCL) or Computer Supported Cooperative Work (CSCW) (Rosenberg & Hutchison 1994). One common component of these types of systems is a online discussion forum, where students and teachers can collaborate and discuss issues or problems. The screenshot below illustrates a discussion taking place between a number of students, on a Java programming course. One student has posted a question, shown at the top of the screen, and other students have given some feedback and advice, listed at the bottom of the screen.

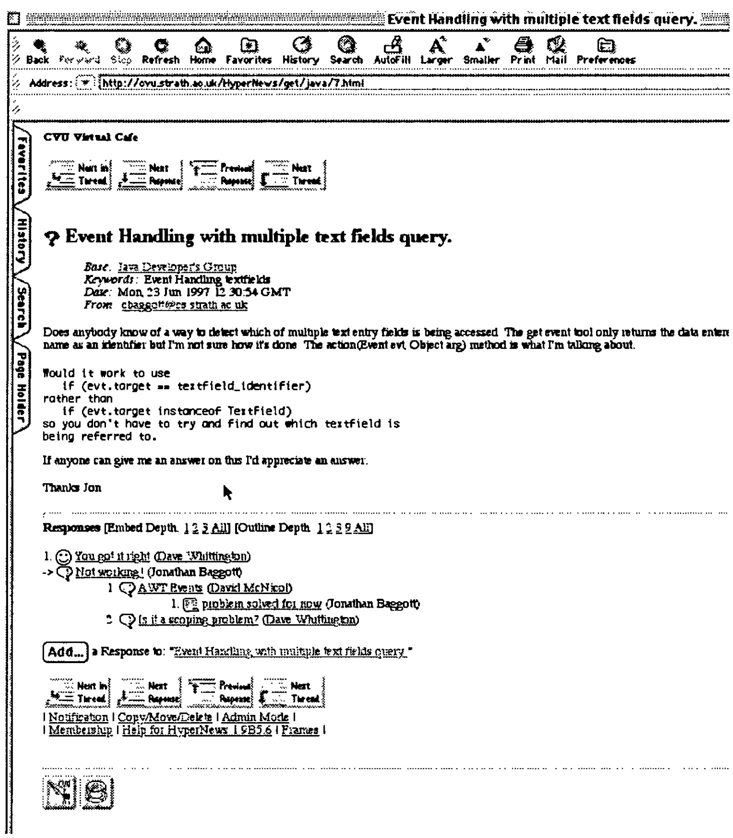


Figure 14 Screenshot from online discussion forum. http://cvu.strath.ac.uk/HyperNews

2.2.3 Laurillard

Although there is evidence that Constructivism is sometimes being adopted in its extreme forms — e.g. the Medical Faculty at the University of Glasgow have moved to replace 95% of their lectures with student-centred, problem-based learning — this extreme approach is still not common in universities today; there is still some resistance to move away from the 'talk & chalk' traditions of the university system since there has to be investment in a complete course redesign to replace the teacher-centred lecture approach to university teaching. Also, some academics feel that this old system has worked well enough over the last few thousand years so why change it now? Laurillard's Conversational Framework (1993) takes a more moderate view of the teaching and learning process, giving more equal roles for the teacher and student, allowing there to be a mix of the instructivist and constructivist approaches, as illustrated in Figure 15.

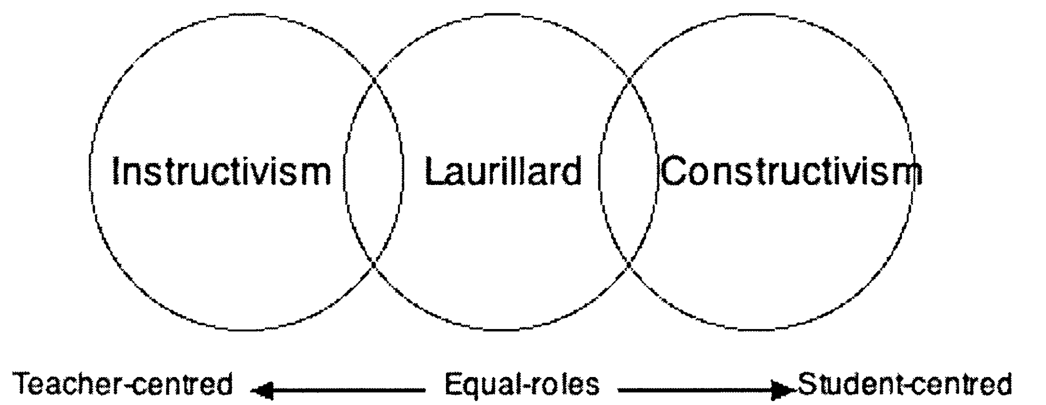


Figure 15 The role of teacher and student in educational theories.

The conversational framework identifies twelve activities that should be performed by the teacher and student for each learning objective.

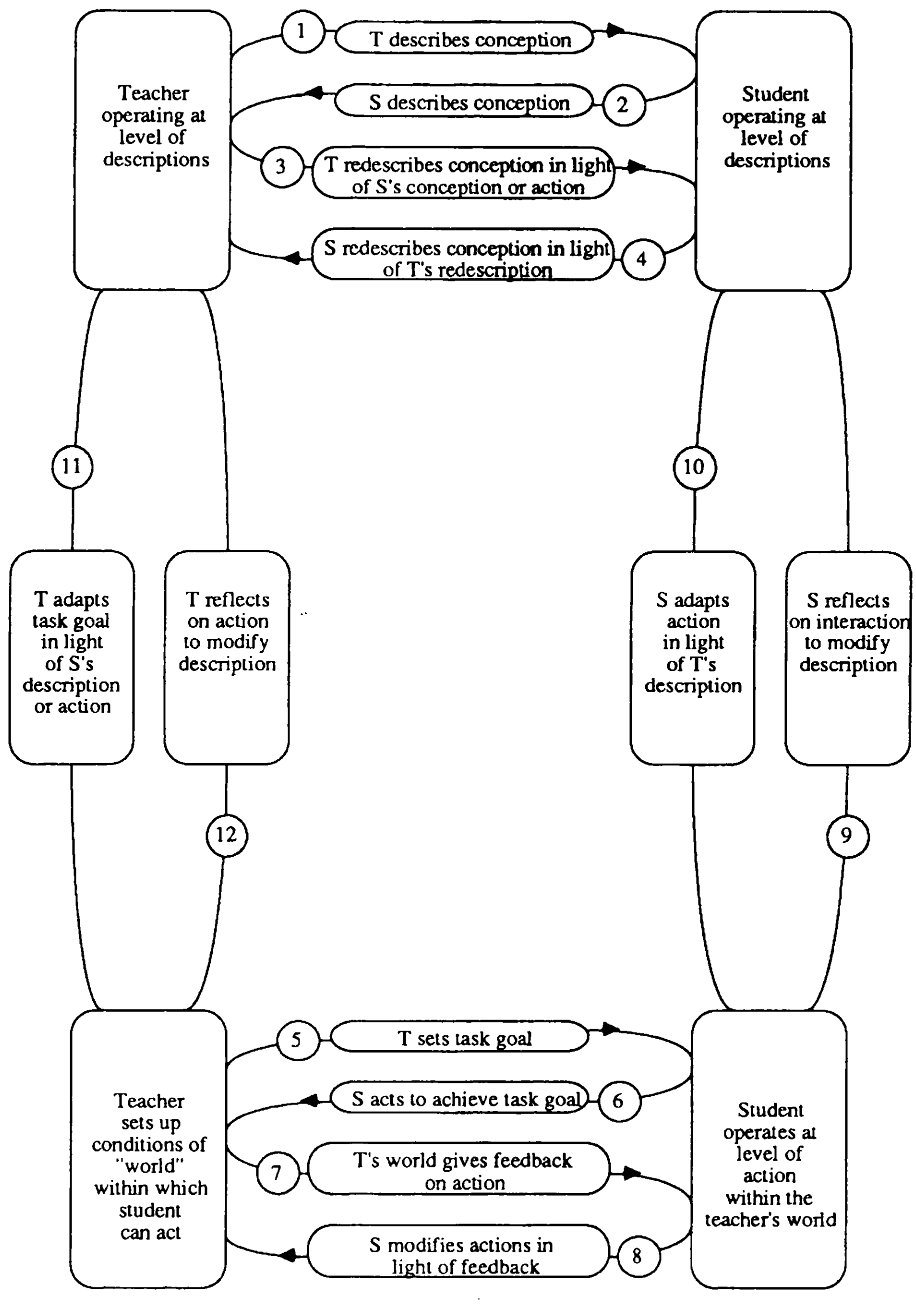


Figure 16 Laurillard's Conversational Framework, adapted from "Rethinking University Education", Routledge 1993, p103.

The twelve activities are described as *mathemagenic activities*[4]. These activities fall into four categories: discursive, adaptive, interactive, and reflective.

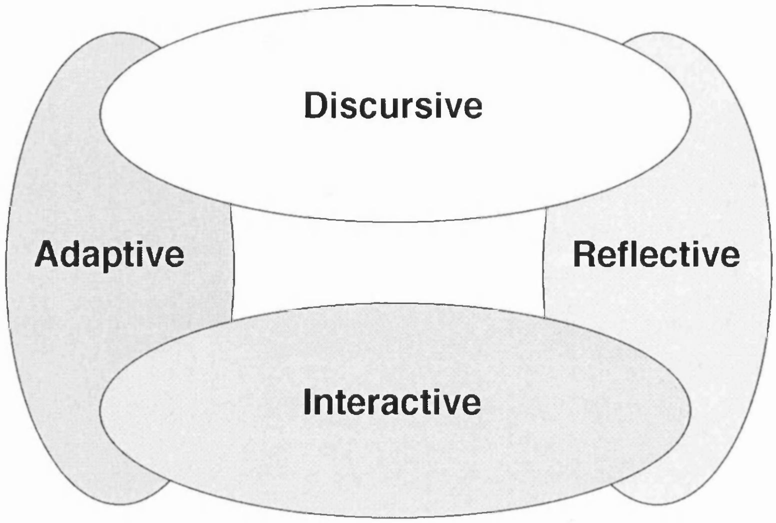


Figure 17 Conversational Framework categories.

This approach acknowledges that any single type of teaching event, unlike Instructivism, does not reliably cause learning. As the name suggests, the conversational framework emphasises a conversation or dialogue between student and teacher, a more interactive view of teaching and learning than the teacher-centred instructivist view.

The fundamental idea behind the conversational framework is that the teaching and learning process is a dialogue, a conversation in which both the teacher and learner participate, an idea influenced by the work of Pask's Conversation Theory (1976). Laurillard states that, in the university setting, there are two levels of conversation for academic subjects. The first level is at an academic level, where there is a shared vocabulary of words, this is known as the level of descriptions e.g. mathematical formulae, technical terms. The second level is at a more personal, experiential level, this is known as the level of actions.

[4] activities likely to promote learning.

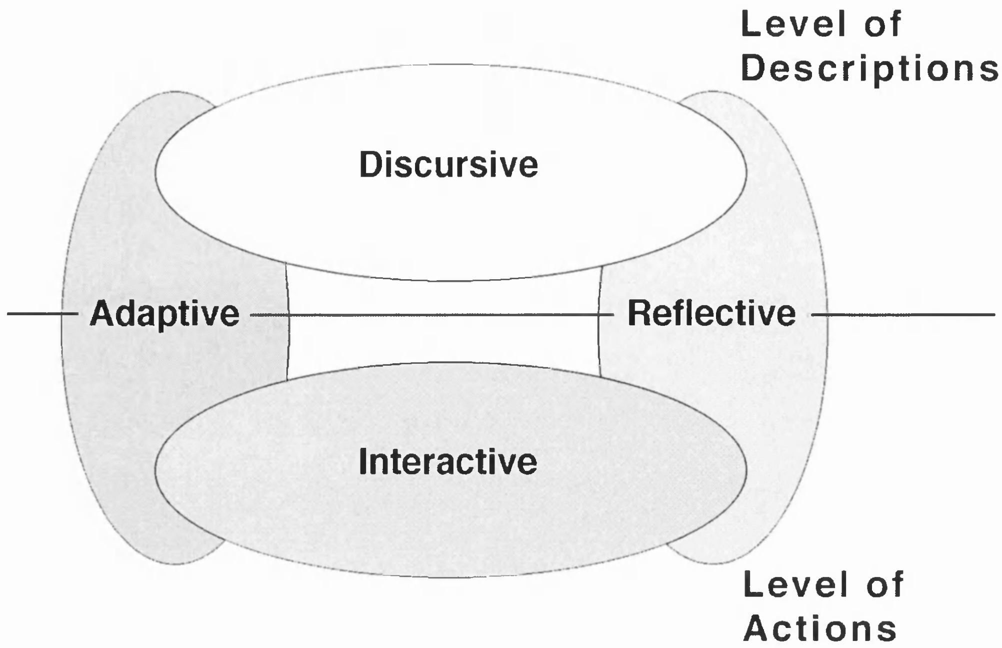


Figure 18   Conversation Framework categories, indicating the two level nature of knowledge.

A key aspect to effective learning is then to make connections and links between the two levels — between the level of descriptions and the level of actions.

It is easy to see from the conversational framework diagram (figure 16) the conversation flow between teacher and student: there is a dialogue going on between the parties. The upper section of the diagram (activities 1–4) is concerned with the level of descriptions, the lower section (activities 5–8), with the more personal level of conversation, is at the level of actions. The middle section (activities 9–12) links the two levels of conversation together. Here both parties reflect on, and adapt activities based on, the other's actions and activities.

The twelve actions can be summarised as follows:

Discursive

1. Teacher delivers the main exposition.

2. The learner describes the conception as he or she understands it, e.g. in the form of an essay or verbally.

3. The teacher re-describes the conception to the student based upon activity 2 and provides feedback.

4. The student re-describes his/her original attempts.

Interactive

5. The teacher sets a task goal for the student to complete.

6. The student attempts to achieve the task set at activity 5.

7. The teacher provides feedback regarding the student's attempts at the task.

8. The student modifies his/her actions in the light of the feedback provided to them by the teacher.

Reflective

9. The student reflects upon the interaction at the personal level of the world in order to modify his/her conceptual descriptions.

12. The teacher examines the student's actions and expresses help at the level of descriptions i.e. explaining what went wrong rather than showing what to do to correct it.

Adaptive

10. The student modifies his/her actions in the light of reasoning at the public level of descriptions.

11. The teacher modifies the task set to address some need revealed by the student's descriptions.

Designers of CAL systems often say that it is the interaction between student and system that makes a system effective or not (Phillips 1996, Sims 1995), a factor that Laurillard has also identified as important. Interactivity is "a necessary and fundamental mechanism for knowledge acquisition and the development of both cognitive and physical skills" (Barker 1989). Interaction may be implicit in the mind of many designers but it has not been explicitly represented in previous instructional design methods.

Laurillard's Conversational Framework is not the only educational model or framework that accommodates Constructivism in some way. There are many others: Bruner's Discovery Learning Theory (1962), Ausubel's Expository Learning (McInerney & McInerney 1994) and Johnson & Johnson's Cooperative Learning (1994).

Bruner believes, like other constructivists, that learning is an active process in which learners build new knowledge based upon their current and past knowledge. Bruner believes that learners should discover new principles or concepts for themselves. The role of the teacher in this educational model is as a facilitator, providing learning materials and learning experiences in a suitable format for the learner to 'discover' from. This educational model follows the Endogenous form of Constructivism as described by Moshman (1982).

Expository Learning has a focus on planned systematic instruction by the teacher which at first seems inconsistent with constructivist principles. However Ausubel (Learning (McInerney & McInerney 1994) *is* concerned with the construction of knowledge based on the prior knowledge of the learner and his planned instructions puts an emphasis on this; Ausubel suggests that the teacher presents an 'advanced organiser' at the beginning of each lesson. An advanced organiser is a set of general statements about the concepts to be learned. Ausubel believes that this provides the learner with a context for the new concepts and also allows the learner to relate the new concepts to his/her previous knowledge. The remainder of a lesson is then teacher-centred, with the teacher presenting new concepts generally verbally with visual aids. Ausubel's Expository Learning is an example of Exogenous Constructvism.

Cooperative Learning involves a small group of learners, usually 4 or 5. These learners actively work together towards a group task set by the teacher. However each learner is responsible for a separate piece of the task and the overall task can not be completed unless the learners work with their peers cooperatively. This model follows Moshman's (1982) Dialectic model of constructivism.

These constructivist models are however at the vertex points of Dalgarno's Constructivist Pedagogical Theories Triangle — illustrating Moshman's constructivist classification scheme as discussed in section 2.2.2, as shown in Figure 11 — and hence have a bias to one of the three classifications: Endogenous, Exogenous or Dialectic constructivism. The Conversational Framework on the other hand, can be placed in a number of positions on the Theories triangle depending on the desired emphasis in the teaching and learning. It is therefore a more flexible model for Higher Education.

As can be seen from Figure 12, Laurillard's Conversational Framework is a good integration of those elements of constructivism usable in Higher Education.

Constructivist Elements	Laurillard Instantiations
Endogenous	Learner Activities, Teacher and Learner adaptation
Exogenous	Activities at the Level of Descriptions
Dialectic	Activities at the Level of Actions & Activities within the Discursive and Interactive categories

Figure 19 Laurillard Instantiations of Constructivist Elements

Jonassen et al (1992) defined a continuum of knowledge acquisition as follows:

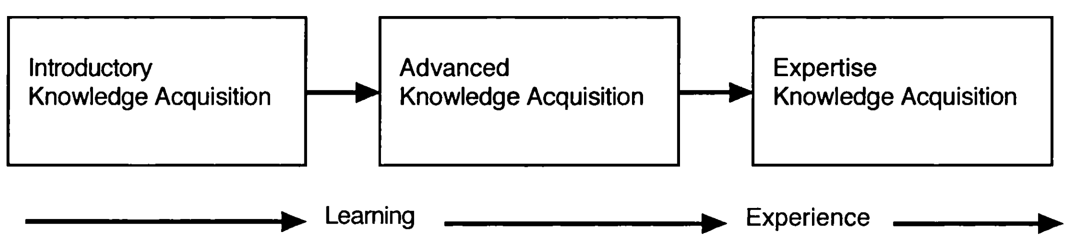


Figure 20 Jonassen et al Knowledge Acquisition continuum

If this continuum is mapped[5] on to Higher Education, the diagram now looks as follows:

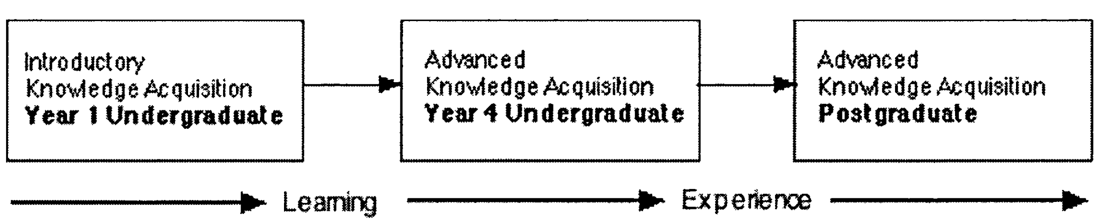


Figure 21 Knowledge acquisition continuum with Higher Education levels highlighted

Jonassen et al believes that constructivism is particularly suited for advanced and expert levels of knowledge acquisition. This matches Moshman's description of Dialectic and Endogenous constructivism. The introductory level of knowledge matches the

[5] This rough mapping is based on the common curriculum of UK Higher Education.

Exogenous constructivism. Laurillard's conversational framework can "tend" to each of these constructivist varieties according to the particular level of Higher Education that an educator wants to address. For example, more emphasis can be placed on the discursive category of activities for a first year undergraduate course, contrasted with less teacher exposition but more emphasis on the reflective and adaptive activities for a post-graduate level course.

Laurillard's model of teaching and learning has received wide acceptance in Higher Education today, evident from the number of research projects that have used the Conversational Framework as a starting point. Three of these research projects are described below.

2.2.3.1 Laurillard Related Research

The MCCA Visualization Tool

The Mediated Conversations for Cognitive Apprenticeship or MCCA (Carey et al, 1998) is a visualisation tool for instructional designers to represent mediated conversations in the cognitive apprenticeship (Collins et al, 1989) model of learning. To create the MCCA, Carey et al adapted the Conversational Framework for use within the Cognitive Apprenticeship model of learning. Carey et al (1998) states that the adapted framework provides a visualisation tool (MCCA) which 'coalesces individual learning tasks into a set of diagrams that represent an abstract view of the conversations within the learning process.'

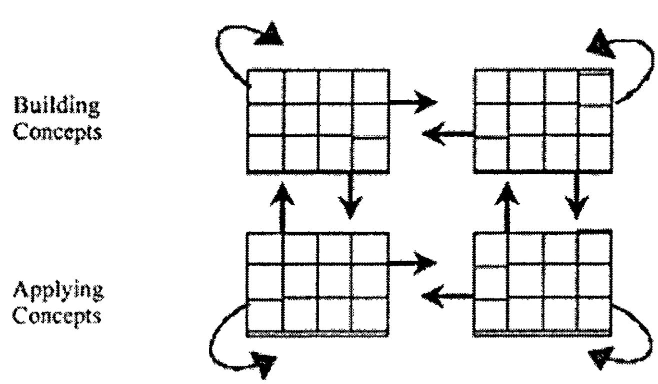


Figure 22 An MCCA Diagram. (Carey et al. 1998).

A key aspects of the Cognitive Apprenticeship approach to education is that learning an intellectual task should be supported in the same way that apprentices would learn traditional trades i.e. through a process of expert modelling, 'watching the master at work,' and through scaffolded support (Collins et al, 1989). Scaffolded support is teacher support that can be scaled up or down as appropriate with a particular learner and learning task.

Figure 22 shows an example of an MCCA diagram. It can be seen from the diagram that Laurillard's (1993) view of teaching and learning at two levels, the level of descriptions and the experiential level, is represented in MCCA. In MCCA the levels are known as "Building Concepts" and "Applying Concepts". The four large boxes in Figure 22 provide the structure for the four types of learning activities:

1. The expert modelling the process of building a concept space (upper left box)

2. The learner building a concept space (upper right box)

3. The expert modelling the application of concepts in the real world (lower left box)

4. The Learner applying the concepts to the world (lower right box)

The arrows in the diagram represent the conversations going on between expert/teacher and learner. Each large box contains a grid of twelve squares. Each square represents up to five minutes of learning time, so each large box represents an hour. Each column of squares represents a conversation. An instructional designer then uses this visualisation tool to build up a picture of his or her instruction, deciding who is having the conversation, at what level and what time. They can then build up a visualisation of the instruction.

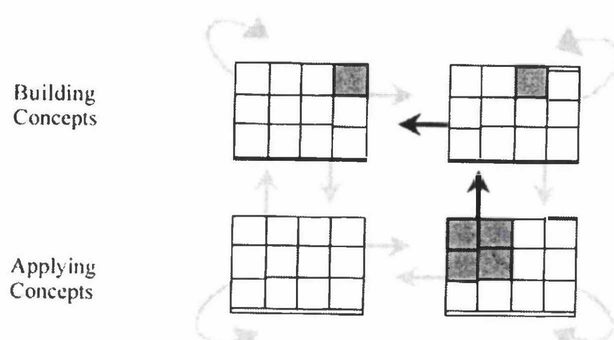


Figure 23 A completed MCCA Diagram. (Carey et al. 1998).

Figure 23 represents part of a completed instructional plan. From this diagram we can see that the major learner task was an application problem, the learner drew on his/her own conceptual understanding and that the learner was prompted to engage in reconstructing the expert's concepts as a clarification. These MCCA diagrams can they be taken down to a lower level of detail in order to work out how the conversations were triggered or to find out the topics around which the conversations happened. Carey et al (1998) report that in usage of the MCCA tool, novice instructional designers found it useful to incorporate cognitive apprenticeship principles in their design and that expert designers found it useful to get a gestalt view of the learning conversations for critique and discussion.

LaTID project

Research done by Conole & Oliver (1997) has produced "A Pedagogical Framework for Embedding C&IT into the Curriculum." Laurillard's Conversational Framework once again was used as the basis for this framework. This work focuses on Laurillard's work on the media types that can be used to support learning activities (Laurillard 1993, Part II). Units of time are identified for the costs involved in developing an activity supported by a particular media type:

Media Type	Examples of organising the structure.	Development of new resources (in hours)	Evaluation of existing resources (in hours)	Resources required
Asynchronous Bulletin board	Set up forums and write activities	2-5	0	BB software
Audio-vision	Prepare script and record, write handout	50-200	5-30	Recording equipment, script
Audio-cassette	Prepare script and record	20-100	2-10	Recording equipment, script
Broadcast TV	Prepare script and record	[illegible]	[illegible]	Recording equipment, script
Email	Define use	0-1	0	Email software
Fill in the gaps	Design and word process fill in the gaps	5-20	1-5	-
Hypertext	Produce HTML documents and gifs	2-10	5-20	HTML editor, browser
Microworlds	Author microworld or provide accompanying explanations	[illegible]	[illegible]	NMPC, microworld software, authoring software
Multimedia	Author material and record clips	100-300	5-30	NMPC, Multimedia software (authoring, graphics, and audio)

Figure 24 *Extract from Conole, G. & Oliver, M. (1997). A Pedagogical Framework for Embedding C&IT into the Curriculum (Online). Available via WWW – http://www.unl.ac.uk/laitd/elt/report2.htm.*

From this table, figure 24, a designer can get an estimate of time to prepare and implement a learning activity by a particular media type e.g. if a designer decided to use Hypertext to implement his or her learning activity, then it would take approximately 5-20 hours to evaluate existing materials to be converted to Hypertext plus 2-10 hours to develop the actual Hypertext resource. LaTID also provides additional tables to enable a designer to work out which Laurillard learning activity to implement based on a measure of the number of educational interactions that media type can support. See figure 25.

Media Type	T describes concept	S describes concept	T re-describes	S re-describes	T adapts tasks
Lecture	3	1	1	0	0
Print	3	0	0	0	0
Fill-the-gaps workbooks	3	1	2	1	0
Radio	3	0	0	0	0
Audio-Cassette	3	0	0	0	0
Audio-Visual	3	0	0	0	0
Broadcast TV	3	0	0	0	0
Video Cassette	3	0	0	0	0
Tutorial (T/S)	1	3	3	3	2

Figure 25 LaTID's comparison of teaching media in terms of educational interactions.

The interaction classification system is as follows: 0 means that the media rarely supports that activity and 3 indicates that it does support that activity well. From Figure 25 we can see that for Laurillard's Activity 1 — Teacher describes conception — if a designer chooses to use a lecture to implement this activity then it gets a score of 3 i.e. Activity 1 would be well implemented using a lecture. However, if we now look at Activity 2 again with lecture as the chosen media type we can see that, with a score of 1, this media type is poor for supporting the student in the reverse dialogue of the student describing his or her version of the conception. So, based on this information, a designer could decide what media type would give the best support for each of Laurillard's activities.

LaTID, although very useful to designers, is not a complete method in its own right: it deals with a limited part of the design process. It is more suited to being used alongside a complete design method. The MCCA allows designers to design hour-long CAL lessons, within the Cognitive Apprenticeship (Scaffolding) model of teaching and learning. The MCCA would need to be adapted to handle shorter or longer CAL lessons. The Scaffolding model of teaching and learning is placed in the centre of Dalgerno's Constructivist Pedagogical Theories Triangle (figure 11) which allows the MCCA to be flexible dependent on where on the Jonassen's Knowledge Acquisition (1992) the CAL lesson sits. MCCA has not yet been evaluated and hence there is currently no evidence for its effectiveness in helping designers.

Investigating Student-Teacher-Resource Interactions.

The Conversational Framework is also being used in the Vocational Education Training (McKavanagh 2000) sector: researchers in the Faculty of Education at Griffith University, Australia, have been using a generalisation of Laurillard's model to investigate student-teacher-resource interactions. They have been looking at live Web-based flexible learning and asking students and teachers about the forms of the 'conversations' they use. In this way they are evaluating both the courses as they are currently offered against the framework, and the framework itself. As a result of this evaluation they have extended the Laurillard model further to capture more contextual variables that students and teachers had conversations about e.g. discussions regarding equipment that is needed for a piece of the course.

2.3 Summary

In section 2.1 it was shown that, in the past, design methods have been introduced to address problems in areas such as software engineering, HCI and architecture. Section 2.1.4 discussed current design methods for instructional materials and concluded that they were not suitable for Higher Education since they had an implicit model of teaching and learning that Higher Education has moved away from.

From the review of the design literature (section 2.1) in the various design communities, a number of important aspects of design methods were identified, common to many design methods, which should be considered in the development of the proposed design method for CAL.

In summary, aspects that a new design method should consider, include:

1. allow a designer to plan out their design.

2. enable a designer to make their design more objective.

3. encapsulate experience and knowledge.

4. make the design process visible.

5. allow a designer to control the design process.

6. not enforce a sequential design process on a designer.

7. consider the context that a new design will be used in.

8. consider the user of the system and their needs in the entire design process.

9. enable a designer to consider and explore their design decisions.

10. be based on a teaching and learning theory.

Design considerations 1-9 will be discussed in the coming chapters of this dissertation. Design consideration 10 is dealt with here.

Models of teaching and learning were discussed in section 2.2. In section 2.2.3 it was shown that Laurillard's conversational framework encapsulated key components of teaching and learning suitable for Higher Education. Since Laurillard's conversational framework fits well with current Higher Education practices and is able to accommodate different levels of learning in Higher Education, it seems reasonable to assume Laurillard's conversational framework is a suitable model of teaching and learning for Higher Education. Hence the framework would make a suitable basis for a new design method aimed at Higher Education CAL developers.

3 CAL Reviews

In order to ascertain the quality of existing CAL packages, and to give further indications of what a design method should consider, the conversational framework was used as the basis for a review of thirteen CAL packages, mainly from an institutional TLTP project. This chapter describes how the reviews were conducted, and presents the results of these reviews, indicating which activities in the framework are commonly supported in existing CAL packages and how they were implemented.

3.1 How review was conducted

The reviews were conducted at Glasgow University, which was the site of one of the largest TLTP institutionally funded projects — the Teaching with Independent Learning Technologies (TILT) project.

> *"The TILT project, which began in January 1993, is concerned with assisting the widespread effective introduction of Information Technology into teaching methods throughout one university." (Doughty et al 1994)*

The TILT project involved nineteen separate University departments, covering a wide range of disciplines from Dentistry to Zoology, Music to Statistics. Reviews were mostly conducted on the CAL products of the TILT project. One other package was reviewed from a previous research project the reviewer had worked on. Although packages reviewed came mostly from one institution, the packages were developed by separate individuals and on distinct subject matter i.e. came from across disciplines. The packages reviewed were therefore representative of Higher Education CAL in the UK.

Each of the thirteen packages was reviewed in turn (see Appendix 10 for package descriptions). Obviously the reviewer's motivation for using the CAL package was rather different from that of a student using the package as part of a course curriculum: the reviewer was evaluating the package design, not trying to learn from the material contained therein. However, progress through the packages was made in much the same manner a student would: following on-screen instructions, using navigation buttons, accessing help facilities if provided, etc. Notes were taken during package usage, recording comments on instructions given, navigation aids, types of interaction used, interface design, and types of feedback given.

After working through each package, answers to the following questions were sought.

1a. Was a design method used to develop the CAL?

1b. If so, what educational theory was underlying this method?

2. Why was CAL product developed?

3a. Was any evaluation conducted on the end CAL product?

3b. If so, what was the result of this evaluation?

4. Which activities did the CAL support in the conversational framework?

The answers were found in existing publications on the project; reports from the TILT project (Arnold et al 1994, Creanor et al 1995, Doughty et al 1994, Draper et al 1994); or from communicating with the academics or developers involved in the products creation.

3.1.1 Justification of Review Questions

Questions 1a and b will clearly enable the researcher to find out how prevalent use of a design method actually is in a sample of Higher Education CAL development, and test the hypothesis that Higher Education does not follow common design methods, such as ISD, because there is disagreement with underlying educational theory.

Draper (1997) hypothesises that there are no generalisations about the goodness of CAL, anymore than about the goodness of books in education, that refer to technical features of CAL, as opposed to features of an educational situation i.e. Draper hypothesises that it is not CAL's ability to display video, audio or use of hypertext that makes a particular CAL package good — instead it is the match between an educational situation that needs addressing and CAL being able to address this need. Draper calls this "niche-based success in CAL." Question 2 enables the researcher to find out if the developers of the CAL packages in this sample were finding a niche that CAL could fill, or if the developers were simply being technology-driven; getting funding; and *then* thinking of what they could do with the technology. Innovations in teaching methods need to be evaluated and this applies particularly to innovations using technology where there is still some uncertainity about CAL's effectiveness (Coopers & Lybrand 1996).

Questions 3a and b will allow the researcher to find out what evaluation, if any, is typically done in existing CAL development and what results are produced. It will also help to identify if evaluation should be included as a component of a proposed design method.

Question 4 will allow the researcher to discover the commonly supported activities in existing CAL packages, and to find out if there are common gaps across CAL packages that are not supported i.e. areas that a design method could help to support and improve upon.

3.2 Results of Review Questions

3.2.1 1a. Was a design method used to develop the CAL? 1b. If so, what educational theory was underlying this method?

Out of the thirteen CAL packages only one had any design method used in the course of its development. The method used was ISD. These findings, on a small-scale TLTP CAL review, are consistent with the conclusions of the large-scale evaluation study conducted by Coopers & Lybrand (1996): Coopers & Lybrand report that only in "a small minority of cases" did they find any CAL projects which had taken account of pedagogic issues in any systematic way, i.e. used a design method with an explicit model of education underpinning it. As discussed in Section 1.2, the report stated that if guidance had been given to projects on pedagogic issues, considerable time could have been saved, and would have also led to more efficient use of technology.

3.2.2 2. Why was CAL product developed?

Coopers & Lybrand (1996) reported a number of justifications that TLTP projects had given for the development of CAL materials:

- alleviating staff "boredom", allowing staff to escape from routine lectures
- allow staff to avoid handling repetitive teaching
- allow students to undertake experiments which were too expensive or dangerous to take place in real environment
- to simulate situations which are not possible to create in a real environment
- to fill a specific niche in a course

The same reasoning can be seen in a number of the CAL packages reviewed here: the content from the four Library modules were created because library staff were having problems teaching library skills in the traditional way, due to an increase in student numbers — staff could no longer cope with with the number of sessions they had to run to cover all the students who needed library skills. Planner, the project planning package, was created one year into a two year funded project. Planner did not address any specific niche in the teaching and learning, simply it was found to be an interesting topic by the academic involved in the project. The three Dental packages were created to supplement traditional teaching methods and to address a particular problem in the traditional teaching set up: in practical sessions where students were given demonstrations of how to use dental instruments, it was difficult for students to actually see the positioning of the instruments, even in small groups. Use of animations and photographs in the CAL package helped to make this clearer to students. It also allowed students to revise instrument position since access to real patients was limited. The engineering package, Fast Fracture, was originally designed not to be used by the students at all but by the teacher in a lecture situation. It was later decided to let students use the package after they had attended the lecture. The two music packages were created to broaden the range of teaching and learning resources available to staff and students. These packages were also created in order to test the suitability of a technological multimedia approach to the subject area. The Parasitisim package was developed to try out a multimedia approach to teaching materials that had already been created using traditional teaching methods. De Tudo um Pouco, the Portuguese language package, was developed to address a recognised weak spot in the current teaching and learning: the language department recognised that students were not getting enough conversation practice which was key to their success in the language, consequently software was developed to give students this essential practice.

Many of the reasons for development of the CAL discussed above match the reasons found by Coopers and Lybrand in their large-scale study of TLTP packages. Draper (1997) however, does not believe that they are all valid reasons for spending time and money to develop CAL: "Success (in CAL) comes from considering a piece of teaching... identifying what is the main problem with it at present, design a way to tackle that bottleneck... It is not: fund the technology, to get the money think of some way to use the computer; or ... to replace lectures or teachers with computers." The idea of this "niche-based success in CAL," as Draper refers to it, will be considered when discussing the evaluation of the CAL packages below.

3.2.3 3a. Was any evaluation conducted on the end CAL product? 3b. If so, what was the result of this evaluation?

Eleven of the thirteen packages had some form of evaluation performed on them. This ranged from formative evaluation during the packages' development to summative evaluation at the end of development using evaluation methods such as confidence logs (Draper et al, 1994), questionnaires, interviews, and quizzes. Despite having a specialised evaluation group as part of the TILT project, the evaluation results are not conclusive: generally there was an increase in student confidence after using the package in the confidence log but the group themselves recognise that this does not relate definitely to actual learning (Draper et al 1994).

Package Name	F o r m	Su mm ativ e	Evidence
Planner	√		
Library:Co	√	√	Increased student
Library:	√	√	Increased student
How to choose	√	√	Increased student confidence
Dental CAL		√	
Dental		√	
Sharpening Dental		√	Increased student confidence,
Fast		√	
Aquitanian Chant		√	Increased student confidence
18th Century Musicianshi		√	Increased student confidence
Parasitism		√	Increased student
De Tudo		√	Increased student
Um Pouco			confidence, improved exam

Figure 26 Evaluation results of TLTP CAL review.

It is interesting to note that the evaluation of the Fast Fracture package did not produce any increase in students' confidence in knowledge of the subject matter: Fast Fracture was not designed for students — it had not been designed to fill a niche in the teaching and learning situation. In contrast, both the Dental Sharpening Instruments and De Tudo um Pouco were created as a result of identifying a clear niche that the CAL could fill. As well as a reported increase in student confidence, these packages went on to produce improvements in learning outcomes as measured by exam marks (McAteer et al 1996). These results were also validated by an external examiner. The success of these two packages gives weight to Draper's hypothesis that success in CAL comes from correctly indentifying a problem or educational bottleneck that CAL can address.

3.2.4 4. Which activities did CAL support in the conversational framework?

The results can be summarised in the following diagram.

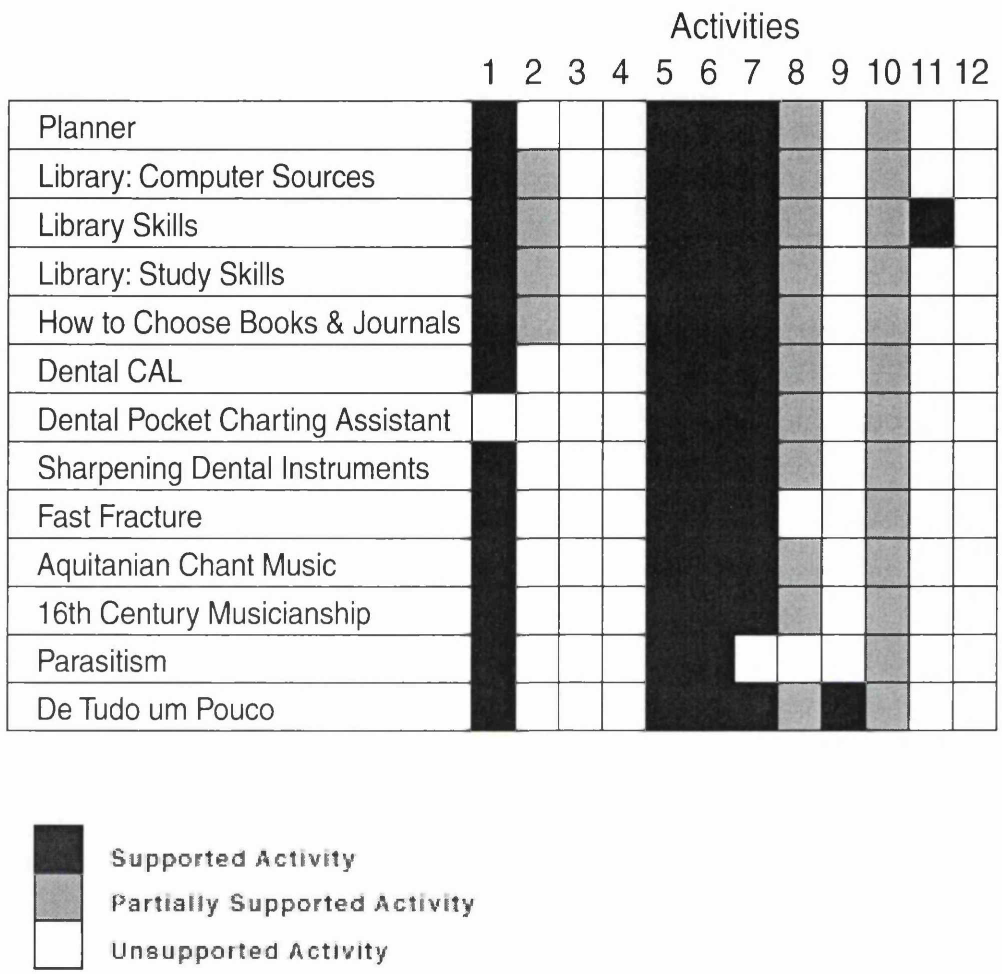


Figure 27 Activities in Laurillard's model, supported by CAL packages reviewed.

At the beginning of Section 3.1, details of how each review was conducted were given. It was stated that the reviewer's motivation for using the CAL package was different from a student trying to learn from it. Notes were taken during use of the package in order for the review questions to be answered. The answers to questions 1-3 were gained from reports and papers written on the packages, or from speaking to the package developers in person. However, the results of question 4 were obtained based on the reviewer's view of how features in the CAL packages supported activities in the Conversational Framework. It could be argued that this is only the reviewer's *interpretation* of what activities in the Conversational Framework the CAL package supported. In order to validate the results obtained by the original reviewer, a second independent reviewer was asked to answer question 4 for a sample of the CAL packages. The independent reviewer (Andrea Chapell, University of Waterloo) was a researcher interested in the use of technology in teaching, and advises academics on this subject. The independent reviewer had been involved in designing CAL packages for their university.

3.2.5 Independent Review

Each of the 13 CAL packages was given a number. The numbers were written on pieces of paper and placed in a bowl. The independent reviewer was asked to draw 3 numbers from the bowl. The numbers chosen corresponded to packages – Planner, Library Skills, and De Tudo Um Pouco. The reviewer was given a copy of Laurillard's Conversational Framework, as it is represented in the ABC method (Appendix 1). The reviewer was asked to follow the same procedure as described in Section 3.1. The reviewer was then asked to complete a table indicating which activities she considered were supported in the package. The completed tables can be viewed in Appendix 13.

The results for Planner and Library Skils matched the original reviewer's results. The De Tudo Um Pouco results matched, except for Activity 9 — the student reflection activity, which the independent reviewer did not mark as being supported. Reflection is a difficult concept for people to initially grasp: Draper has noted that when discussing the Conversational Framework, it is the reflection issues that many people find hardest to address (Draper 1997). Supporting designers' understanding of reflection, and the importance it has in a teaching and learning situation, could be the role of a new design method. The independent reviewer's results overall match the orginal review results, and therefore validate the original results produced by the researcher of this dissertation.

Conversational Framework Review Results

The results summarised in Figure 27 are now examined in detail, looking at how each activity was supported in each of the CAL packages.

Activity 1: Teacher delivers the main exposition.

CAL clearly supports describing a given conception well. The use of text, graphics, and in some cases animation, is used to make the exposition. The Dental Pocket Charting Assistant was the only package that did not support this activity: this was more like a simulation environment than a computer-based lecture. The student was given a set of dental data that they then had to chart and analyse as they would in a real patient/dentist situation. Thus, by its nature, it was not appropriate to describe the initial conceptions. Dalgarno (1996) notes the slow movement away from the instructivist traditions in Higher Education CAL and this is evident by the high number of packages supporting Activity 1 in these reviews. Coopers & Lybrand (1996) also found a large part of TLTP materials were produced in an attempt to "computerise" books and lectures, i.e. presentation of content and exposition. It is, therefore, not surprising that this sample of CAL materials support activity 1 well.

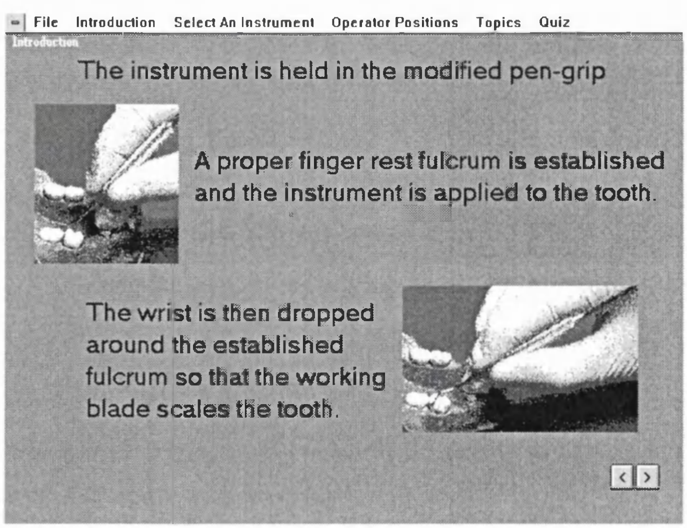


Figure 28 Activity 1 implemented in 'Sharpening Dental instruments' package

Activity 2: The learner describes the conception as they understand it, e.g. in the form of an essay or verbally.

The reverse dialogue, student describing his/her interpretation of the conception, is not so frequently supported. The four packages that did support this activity were a series of modules developed for Libraries that had the same overall structure and format. This suite of packages provided a pop-up notebook facility for students to make their own notes in as they progressed through the package. These notes could then be saved to a floppy-disk and referred to at a later stage. Although there is no actual evidence from the review or project reports of how this was used by end users, this facility could have been used for the student to describe their interpretation of the conception that the CAL package had presented.

Activities 3 & 4: The teacher re-describes the conception to the student based upon activity 2 and provides feedback and the student re-describes their original attempts.

No package supported the third activity in the framework. Since there is, generally, no explicit way for the student to express their view of the conception, it follows that the CAL package in the role as teacher, can not interpret this and offer a redescription of the conception if any discrepancy occurs between the student and teacher versions. Following the same logic, the fourth activity is not supported even in the case where the notebook is used to support activity two.

Activity 5: The teacher sets a task goal for the student to complete.

Setting the task goals posed no real problems for CAL in the packages: Dental Pocket Charting Assistant and Parasitism both contain simulation elements where the prescribed goal is not explicitly stated. They are, however, aiming for a higher level objective or set of objectives, acting in these simulated environments. The type of task goal varied among the packages. Some packages posed a question with multiple choice answers that a student could quickly select from. Others posed a mathematical type question that a student had to work through.

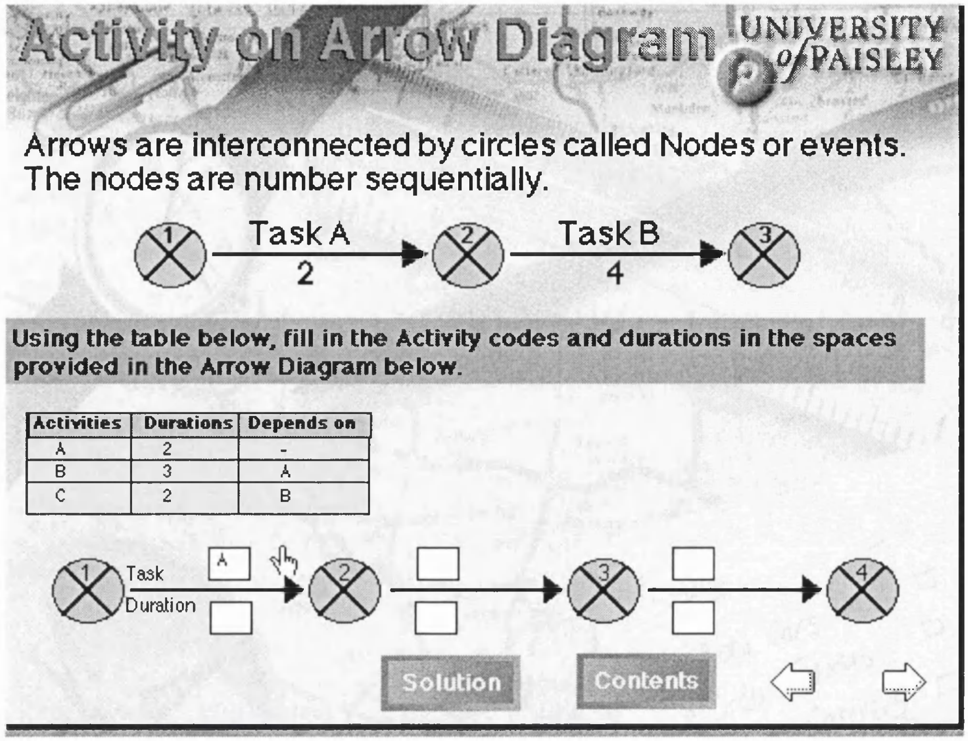


Figure 29 Activity 5 implemented in Planner CAL package

Activity 6: The student attempts to achieve the task set at activity 5.

The CAL packages reviewed allowed the student to achieve the task goal in a number of ways: by clicking on text; dragging text around the screen; entering numeric data; entering freeform text; clicking on appropriate sections of a diagram; recording their voice.

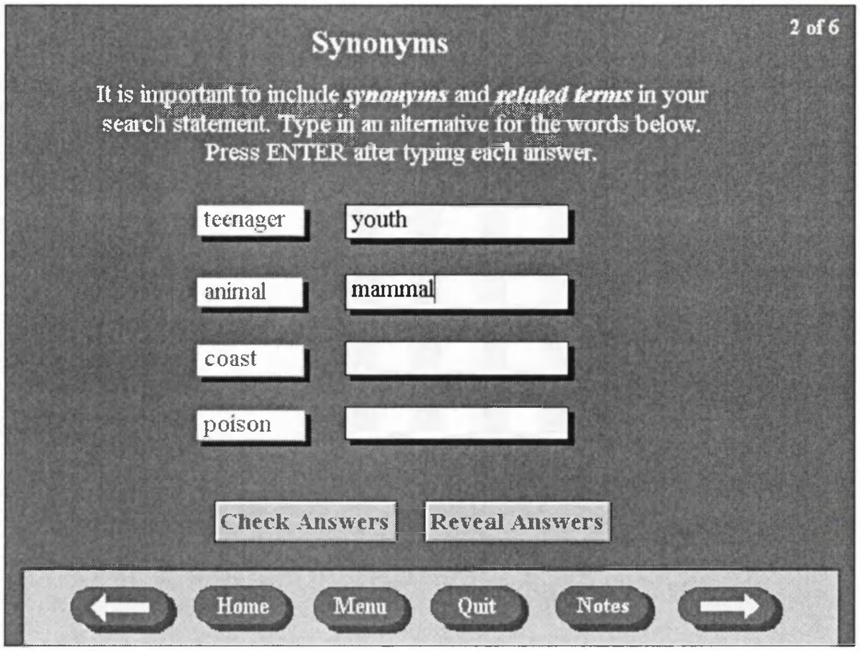


Figure 30 Activity 6 implemented in Library Skills CAL package

Activity 7: The teacher provides feedback regarding the student's attempts at the task.

Laurillard (1993) states that:

"action without feedback is completely unproductive for a learner." p61

On first glance it appears that feedback is a well-supported activity in the reviewed packages. However, if we examine them more closely and look at the types of feedback that students are given, in some cases it is no more than a 'Yes/No' response. Laurillard later stated that:

"Feedback has to be meaningful... A simple 'right' or 'wrong' gives the learner no information at all about how to correct their performance, only that correction needs to be done."p62

The Library suite of packages were good at giving what could be described as meaningful feedback by giving a hint or indication to the correct answer, or an explanation of why the student's response was wrong. The Dental CAL package responded to an incorrect answer by offering to return the student to the section of the package that the question covered, allowing the student to review the theory again. The Parasitism package gave no feedback on the data that students entered for the simulation. However, since this package was a simulation package, the student's actions in Activity 6 are entered into the simulation model resulting in intrinsic feedback via the way the simulation model reacts to the student's input. This means, however, that there is no extrinsic feedback to the student, which is commonly used in educational teaching and learning contexts.

Activity 8: The student modifies their actions in the light of the feedback provided to the student by the teacher.

In light of the quality of feedback given to the student, they were able to re–attempt the task goal. If the feedback had been of the non-meaningful variety, i.e., Yes/No, it could be argued that the student was merely guessing at the answer. The Fast Fracture and Parasitism package did not allow students to re–enter their modified response. Supporting this activity in a CAL package is relatively easy for developers, since in many cases it will be a repeat of Activity 5, hence the large number of packages supporting this activity.

Activity 9: The student reflects upon the interaction at the personal level of the world in order to modify their conceptual descriptions.

De Tudo um Pouco, the Portuguese language package, was the only package that provided support for the student to reflect on the interaction with the package. This package enables students to practise their language skills by placing them in real life scenarios, e.g. buying food at a market. The computer records responses. The package then allows the student to repeatedly play their recording or that of a native speaker, in order to compare and reflect on them. It has already been discussed in Section 3.2.4 that reflection is an activity that many people find difficult to understand, and this is certainly reflected in the number of packages in this review that have not supported it.

Activity 10: The student modifies their actions in the light of reasoning at the public level of descriptions.

It is difficult to imagine how activity 10 can be supported in any CAL package. This activity could involve the teacher describing something conceptual and the student translating this to some adaptation in their practical actions. This appears to be an activity internal only to the student.

Activity 11: The teacher modifies the task set to address some need revealed by the student's descriptions.

The Library Skills package was the sole supporter of adaptation of a task, based on the student's description or action. In this case, it was based on the student's response to questions set by the package. For example:

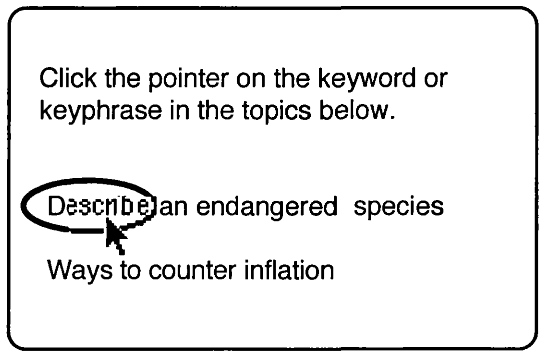


Figure 31 Recreation of screen in Library package

If the student clicks on the word "describe" in the first phrase, the package responds with: "Wrong — Think what are you being asked to describe?" The package, rather than simply informing the student that their response is incorrect, re-asks the question in a different way.

Activity 12: The teacher examines the student's actions and expresses help at the level of descriptions i.e. explaining what went wrong rather than showing what to do to correct it.

None of the packages reviewed handled teacher reflection and corresponding modification of their descriptions. This does not seem to be a difficult goal to achieve and support, compared to activity 10 — student reflection. Since the results of activity 7 indicate that students' responses can be interpreted in some manner, "canned" modified descriptions could be presented to the students based on their responses.

Laurillard does not believe that any one teaching method, CAL for example, can support all twelve activities in the conversational framework (Laurillard 1993). She believes that the teaching methods involved in the whole teaching and learning process should supplement each other. The majority of the reviewed CAL packages were used along-side other traditional teaching methods such as lectures and tutorials. It is in these other methods that support would be given to activities that CAL did not provide for. For example, essay questions could be set to elicit student descriptions of a topic.

3.2.6 Other review results and observations

Some other general observations were made, such as aspects of the CAL packages that the reviewer found useful. Each of the Library packages gave a time indication of how long it would take to complete the package. This was a useful gauge for a user to estimate how long the package was, in the same way one would look at the size of book and estimate how long it would take to read. Another tool in the same vein was a page numbering system, page 1 of 5 say, again giving the user an indication of the length of the package. Past history indicators were also found to be useful, such as a hyperlinked menu structure which indicated by colour when a section of the package had been completed.

3.3 Coverage of Laurillard Categories

As stated earlier, Laurillard identified four categories of activity important in the teaching and learning process: discursive, adaptive, interactive, and reflective. The remaining sections of this chapter analyse the coverage of the four categories in the CAL packages reviewed.

3.3.1 Discursive Category

The first four activities represent the discursive category of the conversational framework. It is clear from figure 15 that only one side of a dialogue or discussion is taking place. These results indicate that, despite the potential technology has for replacing the one–to–one tutorial (seen by Laurillard as the ideal teaching and learning scenario), the CAL packages reviewed failed to capture this discursive element.

3.3.2 Interactive Category

Activities 5-8 cover the interactive category. It appears from the summary of results that interaction is well supported in CAL but, as indicated earlier with feedback, it is the type of interaction that is significant. In Sims' classification system of interaction (Sims 1995) this goal-action-feedback would be classified as *update interactivity* and defined as:

"...events in which a dialogue is initiated between the learner and computer generated content. For this concept, the application presents or generates problems to which the learner must respond: the analysis of the response results in computer-generated update or feedback."

Sims reaffirms the importance of this category, stating:

"The planning of update interactivity is extremely important... the quality and format of media as a component of the update and feedback will affect the overall effectiveness of the instruction."

This would indicate that a design method that helps to support the interactive activities would help to improve the effectiveness of the CAL packages produced.

3.3.3 Adaptive Category

The adaptive category is covered by activities 10 and 11. This seems to be a category on which CAL should have scored well. A long history of tutoring systems based on artificial intelligence principles — Intelligent Tutoring Systems (ITS) — have always done this rather well (Psotka, Massey & Mutter 1988). However, implementing artificial intelligence is a difficult and specialised task, therefore it is probably down to a developer choosing not to include adaptation rather than technology not allowing it to happen.

3.3.4 Reflective Category

The final category — reflective — is covered by activities 9 and 12. In the packages reviewed, reflection is not generally considered. Laurillard says of ITS systems:

"The record of student experiences as far as performance is available to the system...It can therefore call on a great deal of information pertinent to the task of reflecting...the ITS is the only medium, that can be said to support genuine reflection..." p161

However, much more could still be done to encourage this activity by simply providing students with facilities to go back to theory when they are working through a task.

3.4 Review Conclusion

So, in conclusion, these packages showed that the Discursive and Interactive categories are most frequently supported in current CAL packages designed without an explicit design method. However the occasional supported activity in other categories suggests that it is also possible to support these other categories.

The clear gaps in the activities supported in reviewed CAL packages, provide further motivation for exploring the use of an explicit design method based on Laurillard's conversational framework. It is proposed that this design method would focus more attention on key elements of CAL design, the interactive category for example by forcing developers to work out if each activity is adequately supported. It would also provide a framework for educational developers to consider the pedagogic issues in their CAL software, previously identified as being important to the overall effectiveness of the software (Coopers & Lybrand 1996, p28).

4 Development of the Activity-Based CAL (ABC) Design Method

This chapter considers how the proposed design method — called the Activity-Based CAL Design method or ABC method — was created, given the selection of the conversational framework as the theoretical basis. The ABC method began as an outline method based on the design considerations for a new method, identified in section 2.3. This outline method then required refining. This refinement was facilitated by the use of a scenario that refined the method into a complete and useable method. The complete ABC method can be found in Appendix 1. The unrefined and refined methods are compared, indicating the differences that the use of a scenario made. The use of scenarios in evolving the design method was an original technique for creating new design methods.

4.1 The ABC Design Method

Before discussing the creation of the ABC Design Method, a brief overview of the final method is provided. The ABC Design method consists of the following sections:

1. Conversational Framework

The Conversational Framework is described, and its application in the ABC Design Method is shown.

2 Cost and Time Issues

Important in all CAL development is the cost and time involved in producing the end CAL materials. A metric is given to enable developers to estimate the time to produce their new materials.

3 Aims and Objectives

The starting point for the CAL design is writing aims and objectives to focus the developer's mind. A short tutorial is given on how to write aims and objectives.

4 Activity Implementation Chart

The Activity Implementation Chart describes various examples of implementing activities from the Conversational Framework dependent on the teaching method chosen (the teaching method could be by a human, computer, or by some other means.)

5 CAL Case Studies

The Case Studies illustrate via screenshots how activities in the Conversational Framework have been implemented in previous CAL packages.

6 The Design Method

A step-by-step guide to introducing CAL into the curriculum is presented for the developer to work through.

7 Design Templates

Blank design templates are provided for developers to photocopy and use in their design projects. These templates guide the developer in the issues that they need to consider in the design process.

The full ABC Design method as presented to designers is reproduced in Appendix 1.

4.2 Approaches to creating design methods

At a British HCI group workshop on “Usability and Educational Software Design” (December 1997), it was stated that educational design is a craft not an engineering process. Shneiderman (1992) says, “Design is inherently creative and unpredictable.” CAL design can be made less dependent on the particular skills and talents of a few artisans by applying some science to the design process, embodied in an explicit design process. As Shneiderman goes on to say “in every creative domain, there can also be discipline, refined techniques, wrong and right methods, and measures of success.” In order to impose such a discipline, it was necessary to find some way to use Laurillard’s conversational framework in an instructional design setting. The discipline comes from the imposition of the conversational framework on to the CAL design process by the instructional designer. To make this a reality, it was necessary to identify when and how to use the conversational framework.

Observational techniques, such as video recording or interviewing, have in the past been used to capture knowledge of the way activities are performed (Newman & Lamming

1995) and thus inform a new method. Ethnographic studies, common in anthropology and sociology research, combine passive observation with detailed interview data. However, since the basis for the CAL design method discussed in this dissertation is an educational model that is not in established practice, these approaches can not be applied to capture the requirements for a new design method. Another approach to capturing requirements for a complete method would have been to give an initial formulation of the method to developers in real design situations and get them to report back on areas that needed further refinement. Any of these empirical evaluation studies require a large investment in time for both the researcher and willing participants in the evaluations studies. An alternative approach was required for the creation of the ABC design method.

4.2.1 Design Methods in Software Engineering and HCI

In Chapter 2, design methods and the reasons for their creation in software engineering and HCI were discussed. These design methods included the Prototyping Model (Pressman 1994) and the Star Model (Hartson & Hix 1989). The Star Model is an example of a user-centred design method (Norman & Draper 1986). As stated in Section 2.1, software engineering design methods used in isolation, such as the Prototyping Model, focus on the system functionality and low-level implementation. In contrast with this, a user-centred design approach places the design emphasis on how a user interacts with a system and formulates a high-level design based on the users' requirements, users' contexts and environments.

A common design tool used at the beginning of a user-cented design is the use of a "scenario". A scenario is "a narrative," "it is a description of context, which contains information about users, tasks and environments." (Karat 1995). From a scenario, a designer can formulate the requirements of a system from the user's perspective (Carroll & Rosson 1992). This allows a designer to begin a high-level design that can then be iteratively improved upon.

4.2.2 A Scenario Example

Before applying a scenario to the problem of developing the new design method, we first consider a scenario in a non instructional setting. This initial scenario helps us to understand the concept of using scenarios in design and illustrates the effect the scenario has on refining a design. The following is a scenario for a personal airline entertainment system that could be given to a product engineer:

> The entertainment system must be able to be used by airline passengers age 16 and above. Some passengers may not have English as their native language. No knowledge of computers may be assumed. The system should allow access to the radio, films, and the airline information services. Any screen to be used must fit in the back of a seat headrest. There is no space for a keyboard. Headphones can be provided to passengers.

From the above scenario a designer can start to formulate an initial design for the personal airline entertainment system:

The scenario gives her/him information about the user of the entertainment system — "age 16 and above". This allows a designer to make assumptions about skills and knowledge of a user and consequently about how they are able to interact with a system. Language information indicates to a designer that his or her system may need to be multilingual. Information about media types that the entertainment system uses informs the designer that the system must handle audio, visual, and textual information. This will then allow a designer to work out how best to present this information to users in order to perform tasks such as selecting a film to view. Information about the physical context and environment of use — "screen must fit in the back of a seat headrest", "no space for a keyboard" — allow a designer to consider the limitations on the design for user interaction with the entertainment system.

The above example illustrates how a simple scenario can aid the development of an initial design, generating thoughts and design considerations in a designer's head. It also allows the designer to evaluate an initial design against the scenario and refine as necessary. Jack Carroll (1995) states that scenarios can help to ensure that computer systems are "easy to learn/easy to use," that they "smoothly augment human activities" by providing requirements-capture and means of evaluating a completed system. MacLean and McKerlie (1995) identified two distinct roles for scenarios:

1. Supporting the generation of design ideas by giving designers concrete cases to think about.

2. Evaluating a proposed design by checking the adequacy of a given design for specific cases.

This dissertation describes a new use for scenarios:

3. Supporting development of new design *methods* by giving method developers a problem context.[6]

This new use is actually a sub class of role 2 as identified by MacLean & McKerlie: developing a *design method* is a special case of *design* where the artifact created is a new method. This is further discussed in section 4.6.

MacLean & McKerlie call type 1 scenarios *envisioner scenarios.* The fundamental idea behind the use of envisioner scenarios is that they "drive...and contribute to the evolving design." (1995, p192). Although scenarios have been used in the past to envision interactions with an implemented system, these statements seem also to apply to the creation of a design method, as illustrated in figure 32.

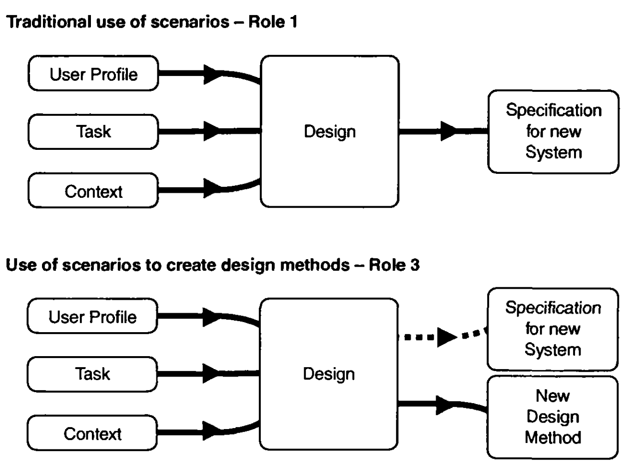


Figure 32 Illustration of possible uses of scenarios

Scenarios allow a design or design method to be iteratively improved upon from an initial design concept, as illustrated in figure 33:

[6] For the avoidance of doubt, the design method being discussed is the complete ABC method as illustrated in Appendix 1, not a CAL application designed with the ABC method.

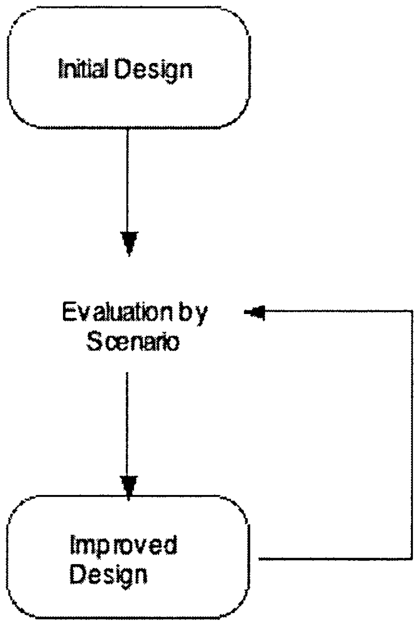


Figure 33 Effect scenario has on a design

4.3 The ABC method before use of scenario

This section discusses the ABC method in its early formulation, before the use of scenarios. The development of the method is shown and then further development when a scenario was used.

The design considerations derived from reviewing design in general and design methods in different design communities, in section 2.3, can be used as requirements for the new proposed design method:

1. allow a designer to plan out their design.
2. enable a designer to make their design more objective.
3. encapsulate experience and knowledge.
4. make the design process visible.
5. allow a designer to control the design process.
6. not enforce a sequential design process on a designer.
7. consider the context that a new design will be used in.
8. consider the user of the system and their needs in the entire design process.
9. enable a designer to consider and explore their design decisions.
10. be based on a teaching and learning theory.

The discussion below describes the initial formulation of the method that aimed to satisfy these requirements.

Instructional System Design (ISD), which was earlier criticised as being out of date with respect to current thinking in educational circles, begins the design process by identifying overall aims and specific objectives for the instruction. Other design methods have also indicated that this is a logical place to begin an instructional design:

"...the objectives of the application are written to clarify what is to be achieved since all further considerations about the learning system depend upon them."

(from Multimedia Design — a newcomer's guide, Department of Employment, 1995)

Therefore it was decided to commence this new design method with the creation of aims and objectives for the instruction. Although this is the same starting place as the criticised ISD, the follow-on is different. Identifying the aims and objectives is the starting point for a designer in planning their CAL application, this satisfies requirement 1.

After identifying aims and objectives, it is necessary to determine if the envisioned CAL package is to be the sole method of instruction or fit into a bigger teaching and learning setting. Implementation of the CAL package can then take place and evaluation of the package follows. Evaluation of the package must take place alongside other teaching methods, if the CAL package is not the sole method of instruction. By explicitly considering, and evaluating, the CAL in the context of use, the CAL design is more likely to succeed and fit well with other existing methods of teaching and learning. Thus requirement 7 is satisfied. The initial formulation of the ABC design method can be represented diagrammatically below:

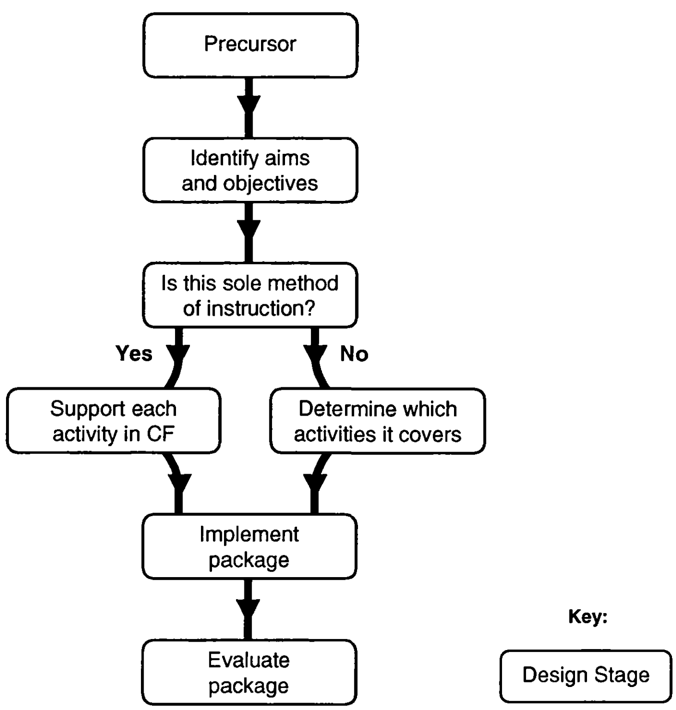


Figure 34 Design stages in the method before use of scenario.

4.4 Refinement of design stages

Prior to the use of the scenario, further refinements of the design stages in the new method, illustrated in Figure 34, were made based on further consideration of the design requirements identified. The refinement of these stages is described below.

Precursor to use of method

At this early stage in the design process it is necessary to provide support for a designer, to question their motives and use of CAL to avoid unnecessary investment in time and money. This support could be given as a series of questions or a form to fill out, forcing the designer to think consciously about the CAL project they are considering undertaking. By questioning his or her design in this way, a designer is able to produce a more objective CAL design. Providing templates that a designer must complete to document his or her design ensures that the design process is visible. It also means that the designer can modify parts of the design and easily follow what implications this has for the rest of the CAL design. In this way the designer is able to control and manage the design process. Thus requirements 2, 4 and 5 are satisfied. Questions asked of the designer could be as follows:

e.g. What are you trying to do with the CAL package?

Why are you doing this?

How will the CAL be used and in what context?

Is CAL the sole method of instruction?

Before designers can make this decision it is necessary to provide them with information about Laurillard's Conversational Framework, the teaching and learning theory that the design method is based upon. This satisfies requirement 10. The information provided will allow them to become familiar with the Conversational Framework and its model of teaching and learning. Designers require some visualization of the Conversational Framework, listing each activity and providing an explanation. This could be called "Activity Example Implementations". Each activity could be illustrated by how it is possible to be implemented in CAL and also by some other teaching method. The "Activity Example Implementations" would encapsulate experience and knowledge that the designer could take advantage of in his or her CAL design.

This satisfies requirement 3.

Evaluate Package

In common with good engineering practice, an evaluation method for developers is required to help developers evaluate the implemented package. At this stage in the development of the design method, support for *some* evaluation has been identified but no details of the evaluation method have been identified.

4.5 Features generated from the initial design method

A number of design features for the new ABC method were generated from the initial formulation of the design method. These design features are aids for the developer:

— Basic question form to complete.

— Conversational Framework visualization.

— Conversational Framework activity example implementations.

— Evaluation method.

These refinements, based on the design requirements for the method, and resulting features have created a refined design stage model with the new design aids, as illustrated in the figure 35:

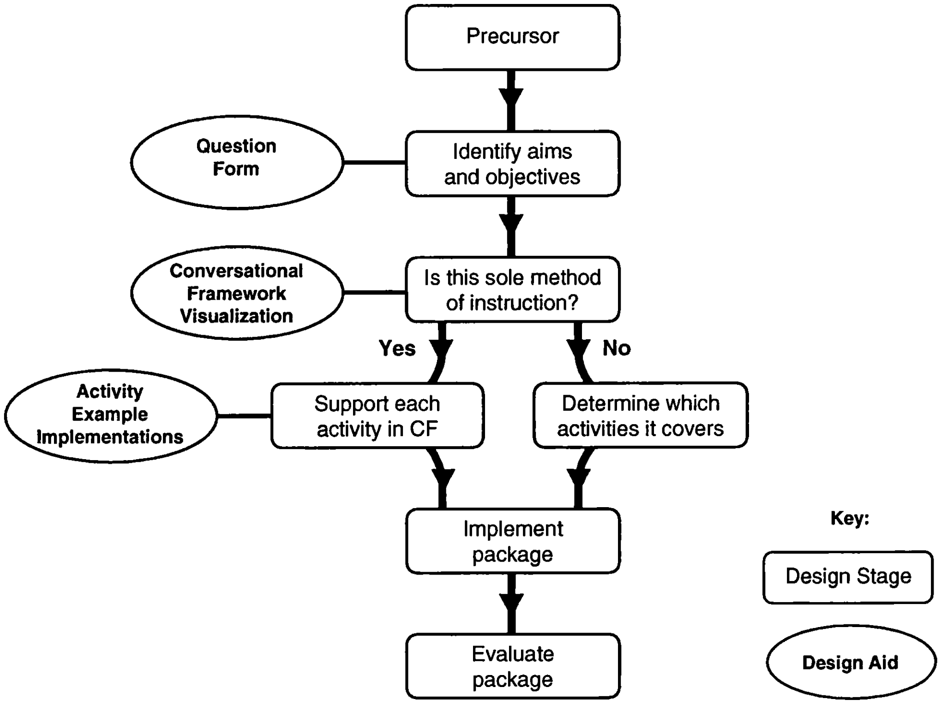


Figure 35 Refined ABC Design Method.

4.6 Design method after use of the scenario

Figure 34 illustrates the initial formulation of the design method. It can be seen that the design method has moved on from this initial design method by comparing it with the refined design method described in Figure 35. Unsatisfied requirements for the new design method remain. The design method should:

6. not enforce a sequential design process on a designer.

8. consider the user of the system and their needs in the entire design process.

9. enable a designer to consider and explore their design decisions.

It is not immediately clear how these requirements can be incorporated into the design method. Use of a scenario may help to identify where these requirements can be supported in the design method. The following sections discuss how the ABC design method is further developed with use of scenarios.

4.6.1 Finding a suitable scenario

A suitable topic for a scenario was sought. Draper (1997) states that the success of CAL is not due to the features of technology but to a close fit between the CAL and a niche that the teacher has identified as a problem area that needs more support. From discussions with colleagues on a first year undergraduate computing science course, it was revealed that a common topic that students struggle with in Ada programming courses is that of Ada Packages.

> *"An Ada Package is a logical unit for bringing together related parts of a program. Subprograms, types and objects that logically belong together in some way can be brought together in a package." (Skansholm 1995)*

It was decided to use this topic as the basis for the scenario to aid the development of the new design method.

4.6.2 The scenario

> *"Design a CAL system that could improve students' understanding of Ada Packages. The students are all first year computing science students taking a further programming module in Ada, having previously completed an introductory Ada course. The main teaching resource for Ada packages is a set of lectures with follow-up tutorials and labs. It is envisioned that the CAL package will be used in the tutorial setting of a first year computing lab. Tutorials typically take one hour."*

This topic was derived from a real setting with the realistic constraints which academic CAL developers face. The setting for the topic — a first year undergraduate computing science course — was also familiar to the researcher which allowed any gaps in the scenario to be filled.

4.7 Refinement of design stages with introduction of scenario

The stages illustrated in figure 35 were refined by the introduction of the scenario. The scenario provided a context to evaluate the design method against and find areas that designers needed further support with. The refinements and developments to the method are discussed below.

Precursor to use of method

Working through the scenario as stated in section 4.6.2, areas were identified where further support for the designer was needed: it would be useful to highlight some issues to the designer that should be considered when implementing a CAL package e.g. investment in time and money involved, number of hours involved in development, anticipated benefits from CAL. Considering these issues would further help the CAL design to be more objective. While working through the scenario, it became apparent that there was insufficient information from the design method on how to order the CAL design: it was necessary to provide the designer with guidance on how to structure and order their design. This refinement also forced considerations of how to present the method to developers.

Suggested Presentation for the Design Method

1. Precursor/Overview.

2. The Laurillard teaching and learning model — the Conversational Framework.

3. Activity implementation chart.

4. Activity implementation case libraries.

5. Design method.

6. Evaluation.

Identify aims and objectives

Working through the scenario confirmed the need for identifying aims and objectives since the overall goal of the scenario — to design a CAL system that could help students understand Ada packages — was not sufficiently scoped for a designer to proceed. Specifying aims and objectives forces a designer to assess the size of problem that the teaching and learning will address. The scenario provides some of this scope by indicating that CAL would be used in an hour-long tutorial. Some designers might not be experienced in the art of generating aims and objectives. A small tutorial on how to create them, providing reference examples, should be supplied. Once objectives are identified, each objective should be applied to the Conversational Framework, working out how each activity will be supported.

Is CAL the sole method of instruction?

Further scope problems were identified after the objective of the teaching and learning had been identified: a designer must know if CAL will be the only method of instruction for the teaching and learning objective, or if it will fit into a wider range of teaching methods i.e should CAL support the objective alone, or will it be supported by other teaching methods. The particular scenario used highlighted the need for developer support in this decision, since the scenario's context offered a number of teaching methods – labs, tutorials and lectures. This view is compatible with the independent finding of the TILT project (Doughty et al 1994) that found that CAL was often not integrated into the rest of the curriculum and consequently did not succeed. This suggests that this is an area that developers overlook and where they need support. To allow developers to decide on how each activity should be implemented, an Activity Implementation Chart should be provided:

Activity No.	**Teaching Mode**	**Example**
1	Human to Human	Teacher delivers lecture
	Human to Computer	Computer uses text and graphics to deliver
	Other	Student reads book which contains exposition of topic
(continued)		

Figure 36 Activity Implementation Chart.

The Activity Implementation Chart describes each Conversational Framework activity and offers 3 possible teaching modes that could be used to support that activity i.e. Human to Human, Human to Computer, or by some other medium e.g. a video or book. The Activity Implementation Chart then provides the designer with textual descriptions of example implementations for each of these teaching modes.

By suggesting a number of different teaching modes to the designer, the ABC method acknowledges that it is difficult for one teaching medium to support an entire teaching and learning experience, and that it is more likely to be a combination of teaching mediums (Ramsden 1992, Laurillard 1993 p.98.) This approach also allows designers to integrate a small piece of CAL into an existing course with other teaching mediums.

This allows designers to "pick and mix" the best medium for a particular activity. From the example Activity Implementation in figure 36, it can be seen that the user – the student – is considered and it is clearly stated what activities the student must perform, if appropriate, for each activity. This can be further seen in the 'Interactive' categories of the conversational framework show in the full Activity Implementation Chart in Appendix 1. This satisfies design requirement 8 which stated that the user of the system must be considered in the entire design process.

Provision of an Activity Design Template would then allow designers to easily record their activity implementation decisions:

Title	Ada Packages	
Aim	Teach students basic components of Ada packages	
Objective	Describe an Ada package, its purpose and components	
Activity No.	**Teaching Mode**	**Description**
1	Human to Computer	Uses text and graphics to describe an Ada package, its purpose and its components
(continued)		

Figure 37 *Activity Design Template.*

Use of the design templates would also allow a designer to explore his or her CAL design. He or she would be able to change the teaching mode and see the impact that this would have on the remainder of the design since his or his design was documented and visible in the completed design template. The designer is able to complete the template in any order. He or she may want to consider the interactive activities first then the discursive categories. The templates provide the designer with the facility to freely explore their design, making changes where he or she feels necessary. Making changes in a design at this stage in the design process is far more cost effective than making changes at the implementation stage. Introduction of the activity design templates allows us to satisfy the remaining three design requirements, 6, 8 and 9: a sequential ordering should not be enforced on the designer, the user of the system should be considered throughout the design process and the designer should be able to explore his or her design.

Implement CAL package

While working through the scenario, a number of resources were identified that would be needed to implement the CAL e.g. text, graphics, audio. It was clear that management of these resources on a larger-scale project would soon become unmanageable. To assist implementation decisions and management of implementation, a second design template could be used:

Title	Ada Packages		
Aim	Teach students basic components of Ada packages		
Objective	Describe an Ada package, its purpose and components		
Activity No.	**Resource Required**	**Resource Acquired**	**Resource Assembled**
1	Text on ADA package	Y	Y
	Picture of Car	N	N
(continued)			

Figure 38 *Activity Resource Template.*

The design templates could be amended to deal with a team approach to the project. Addition of a name field in the design templates would indicate which activity had been assigned to which team member.

Evaluate Package

Before use of the scenario the need for *some* evaluation method was identified. The use of the scenario highlighted the need for a quick and low-cost method of evaluation that would allow fast feedback into the design stages. Following successful use of the Conversational Framework to evaluate existing CAL packages in Chapter 3, the same method is proposed to evaluate newly created packages. Designers complete a table, shading boxes for each activity that is supported, aiming to shade as many boxes as possible. Unshaded boxes would highlight activities to be looked at again. Returning to the original design template, a new implementation could be decided upon or a completely different teaching mode chosen. Performing the iterative cycle illustrated in figure 39, will increase the likelihood of a more effective CAL package by maximising support for the activities in the Conversational Framework.

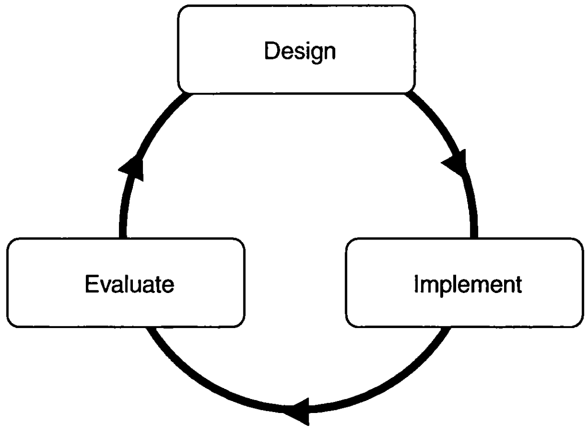


Figure 39 Iterative Design Cycle.

It should be noted that this is a formative evaluation method and that after implementation, the complete CAL package should undergo a more rigorous summative evaluation. Formative evaluation is intended to help modify the design of the teaching and learning activity before its production is finished. This is very important since in practice it is difficult to design a good test activity first time (Draper et al 1994). In contrast, summative evaluation is concerned with the finished product in use, measuring its performance and comparing to similar products. Details on the summative evaluation methods can be found in Draper et al. (1994).

4.8 Features generated from use of scenario

More features or design aids for the method were generated with the use of the scenario: the scenario highlighted areas that designers needed additional help with. These can be summarised as follows:

— Provide overview of issues involved when considering introduction of CAL.

— Structure and content of the design method.

— Tutorial on writing aims and objectives.

— Activity Implementation Chart.

— Activity Design Template.

— Activity Resource Template.

— Evaluation table.

These refinements and resulting features have created a refined design stage model with the new design aids as illustrated in figure 40:

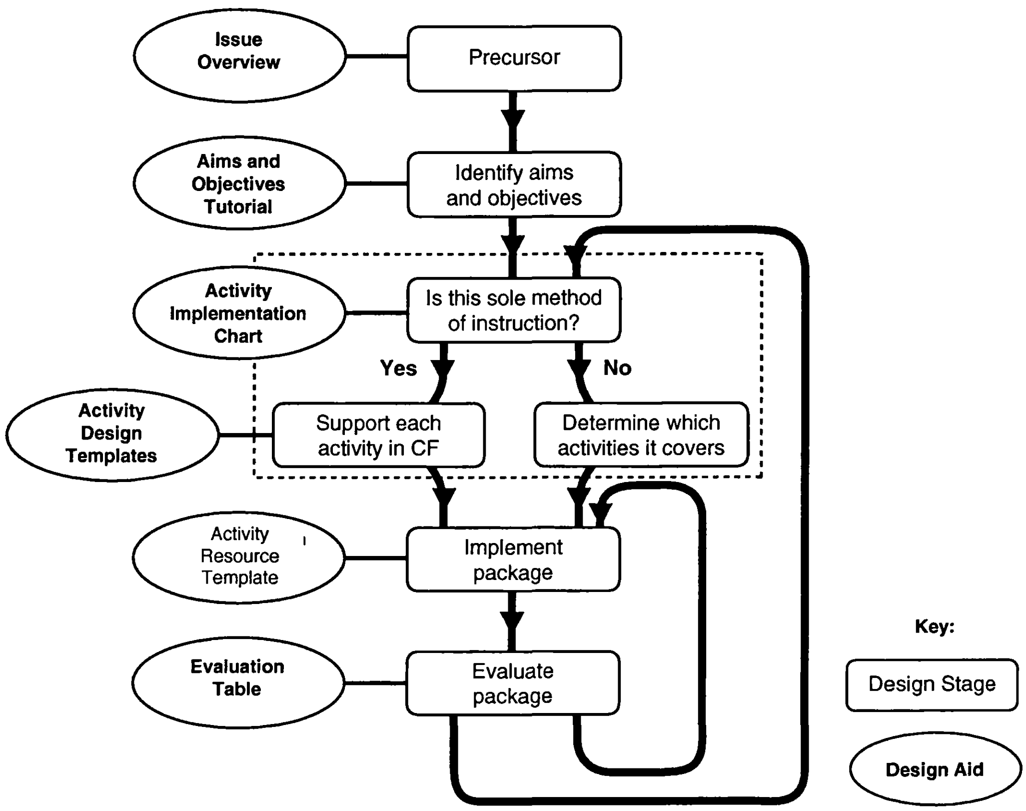


Figure 40 Refined ABC Design Method.

4.9 Comparison of features before and after use of scenario

We can compare the features generated from before and after use of the scenario indicating the refinement in the method that the use of the scenario enforced:

No Scenario	With Scenario
Question form to complete	Provide overview of issues involved in CAL introduction
Conversational Framework visualisation	Structure and content of the complete design method
	Tutorial on writing aims and objectives
Conversational Framework example implementations	Activity Implementation Chart
	Activity Design Template
	Implementation Design Template
Evaluation Method	Evaluation Table

Features for the design method, identified following refinements of the initial formulation of the method and then with the introduction of the scenario, helped to provide a more complete method. These additional features of the design method would better support developers, with design aids such as the Activity Implementation Charts.

4.10 Conclusions

The comparison table above clearly shows the effect the introduction of a scenario had on the ABC design method. Some aspects of the design method were refined and made more concrete e.g. from "Evaluation method" to decisions of a specific evaluation method and corresponding evaluation table. Other aspects of the design method were explored further and details worked out e.g. Conversational Framework example implementations. Although we had identified a number of design requirements for the new design method, using a scenario forced a further development iteration on the design method that resulted in a more complete and supportive design method. Scenarios have previously been identified as an efficient way to generate requirements (Carroll & Rosson 1992).

Use of an enhanced envisioner scenario allowed the design problem – creation of a design method — to be made more realistic and concrete. The scenario provided a setting — an environment — to explore additional requirements for a new design method and to discover what instructional designers — the users — would require from such a design method while performing instructional design tasks. It does, however, remain true that the ABC method was generated through a creative process, not the mechanical application of a systematic method. The scenario highlighted problems of scope that developers often have to face. The scenario chosen in this case provided a rich environment to explore these problems of scope. Further use of scenarios for creating design methods, would need criteria to select and systematically determine what constitutes a good scenario. However, some generalisations can be made that may be useful for other developers of CAL design methods wishing to chose a scenario to aid his or her design method development:

- chose a scenario that embeds the CAL in an existing teaching course. This allows the designer to consider problems of integration with this existing course.

- chose a reasonable size of teaching and learning topic to address. Do not aim to write a CAL package to cover an entire undergraduate course, for example, chose a small manageable chunk.

- know the user population that the CAL should address. It is important to know what knowledge the users of the CAL system already have and what they should know at following use of the CAL system.

5 Evaluation of the ABC method

5.1 General discussion

The claims of this dissertation are:

1. A new design method — The ABC method — can be created based on a suitable model of the teaching and learning process for Higher Education — Laurillard's Conversational Framework.

2. The ABC method enhances the CAL design process, by focussing designers on pedagogic design issues.

If we adopt Laurillard's conversational framework as a more appropriate model of teaching and learning, as discussed in section 2.3, then claim one can be considered to have been satisfied by the creation of the ABC method, as discussed in the previous chapter. This chapter describes research performed to support the second claim.

Evaluation of design methods like ABC can be focussed on assessment of the product it produces or the process it specifies. Product evaluation is attractive since this is what developers are really interested in. For certain products e.g. manufactured goods, it is relatively easy to evaluate the end-product against a list of desired features and attributes. There is, as yet, no such list for instructional materials. End-products could alternatively be judged against a list of development guidelines. Although this is a cheap method of evaluation there is no predictive quality between guidelines and the quality of an end-product (Newman & Lamming 1995). Users of guidelines often do not strictly follow what the guideline advises so there are no guarantees what the end product will be like. Expert evaluation is another method that could have been employed in evaluating the end-product. Extensive field-trials could have been undertaken using the method. However, none of these evaluation techniques are suitable within the time constraints of this thesis and the ability to find large number of academic developers willing to develop complete CAL systems for evaluation and further academics willing to evaluate complete CAL systems.

Empirical evaluation studies that test the products of design were not possible in the time-frame of a thesis considering the time required for development and implementation of materials. This would also involve other developers being willing to invest a considerable amount of time and effort in the evaluation process. Considering evaluations of products after the design stage also introduces a number of confounding variables to an experimental design. For example: technological variables such as the choice of platform to develop for, the choice of authoring tool chosen to develop the CAL materials in, or even the skills of the programmer who implements the design — all add confounding factors to the quality of the end materials. Evaluations, like those performed in Chapter 3 with the Conversational Framework, are also not feasible without an end-product. It was therefore necessary to measure the use of the ABC design method in the design process itself, which stops before the artifact is created.

It is necessary now to consider what to measure in the design process to determine if the ABC method has enhanced the process: by measuring the process we are able to see what difference, if any, the use of the ABC Method has made. We might look for greater innovation, more thoughtfulness in the design, or greater efficiency. Some reasoning and motivation for the work discussed in this chapter has been inspired and influenced by the work of MacLean et al. (1991) on Design Rationale and the QOC representation as discussed in Section 2.2. Their work aimed to:

> *"facilitate innovation and reasoning in the design process by helping designers generate, represent and think through, in a disciplined yet flexible way, their decisions..." p220*

> *"...to help...justifying design decisions and consider other opportunities for exploration." p220*

The ABC Design Method has similar aims for the CAL design process. The ABC method is driven by a pedagogical framework and focuses on pedagogical issues. The use of the ABC design method should result in more discussion on pedagogy, less discussion on concrete interface details and more explicit reasoning in the discussion. Therefore it was natural to look at the evaluation studies conducted by MacLean et al. They evaluated a design by analysing a design discussion and categorising it according to QOC elements. MacLean et al. (1991) used sets of professional software designers discussing a new design for an ATM (automatic teller machine). The designers were video-taped. The videotapes were transcribed and categorized into QOC elements for analysis. They could then see how many different "options" – 'O's – had been considered. A small number of options indicated that the design was not being considered greatly nor exploring the design space fully, thus supporting their claim that there was a need for QOC which would facilitate design exploration and consideration.

The ABC method aims to enhance CAL design. Design discussions can again be analysed, but a different set of evaluation criteria must be used. The Coopers & Lybrand report (1996) stated that the CAL materials they examined contained little pedagogy. So one improvement that the ABC method could make is to increase the amount of attention designers pay to pedagogy, as indicated by increased discussion of pedagogic issues.

It was decided to conduct observational studies of educational designers given a set instructional design task for evaluation of the ABC method. There are several ways the design discussion could be investigated: in the case of the QOC studies, pairs of designers were used and therefore it was easy to record the discussions between the designers. In the proposed experiments only one designer is used so this particular means of getting access to the design discussion is not possible. In Higher Education one designer is typically responsible for the original design for a CAL package, so it seemed appropriate and correct to use only designer in this experiment. Post-experiment interviewing or use of a questionnaire could be used to ask the designer what he or she had been thinking during the experiment but it is easy for people to forget the details of their design process. Participants in post-experiment interviewing also tend to rationalise and summarise their design when recalling it. This would not allow the researcher to see what design detail they were actually thinking during the design process, which is what is of interest in this experiment. Another way to make the design reasoning of the subject explicit is to ask designers to verbalise their thinking process as they perform the task. These verbalisations are known as "think alouds" (Preece et al 1994). However, it has been noted that "the very act of describing what you are doing often changes the way you do it." (Dix et al, 1998). A trade-off must be made in the choice of evaluation technique. Others have successfully used "think alouds" with individual designers when investigating discussion in the instructional design task domain (Goel & Pirolli 1992.) For this experiment it was decided that using think alouds through the design process would give the most relevant data to be able to satisfy the claim that the ABC design method enhances the CAL design process.

5.2 Experiments

Two sets of experiments were performed. The first experiment was a comparative study of designing materials with the ABC method against undirected design. The second experiment compared the new method with another pedagogic design method based on a different model of the teaching and learning process. The second experiment was performed to show that it was the use of the ABC Design method that had made the difference in the design process and not just the introduction of *any* structured method.

5.3 Experimental Design: Experiment 1

5.3.1 Introduction

The independent variable in this evaluation experiment is the ABC Design Method. We are interested in two levels of the independent variable in our experimental design: the presence or absence of the method. The dependent variable is the number of pedagogic issues that the designer produces. This experiment aims to show that use of the ABC method increases the amount of discussion of pedagogic issues by a designer.

5.3.2 Hypothesis

The number of pedagogical design issues (the dependent variable) will be greater with the use of the ABC Method than in undirected design.

5.3.3 Subjects

Two groups of subjects were used to match the two levels in the independent variable: one group were given the design task and trained in the use of the method, the other group were given the same task but allowed to perform the design in any way they thought appropriate. An independent groups design was used where subjects were randomly assigned to each group in the order they replied to an email call for experimental participants i.e. the first person to respond was assigned to group A, the second to group B and then alternating until the groups were full. Twenty subjects participated in the experiments. Most of the subjects were full-time academic members of staff at different Higher Education institutions, across different disciplines. A number were research assistants or postgraduate students. All subjects were engaged in Higher Education at some level. Since a high proportion of the subjects were academics it was felt they were realistic candidates for the ABC Design Method and its uses, since more and more academics are being encouraged to look at CAL as a way of relieving the pressures of heavy teaching loads.

5.3.4 Design Task

The first problem encountered with the experiment was in the choice of a suitable design task for Higher Education. It was important to pick a realistic but discipline–independent design task in order to avoid the confounding variable of subject-matter expertise. Some of the experiments took place while the experimenter visited a research group developing instructional materials for cross-campus consumption. One such example was a standalone CAL package created to teach students Critical Analysis, the art of being able to analyse written work critically, and to be able to write and discuss that work objectively. After reviewing this package it was decided that Critical Analysis was a skill needed for all disciplines and not related to a single subject. The Critical Analysis package was, therefore, used as the basis for the design task.

5.3.5 Operationalising the experiment

The procedure for each experiment is now described:

1. Each subject was randomly assigned to one of the two groups representing the two levels of independent variable. This assignment was done by assigning subjects to a group alternately in the order they responded to an email call for experimental subjects.

2. They were then shown the task as described in Figure 41.

Critical Analysis Software Redesign

The University of ScotCan has been at the forefront of innovation in the use of technology in teaching and learning. One example of such innovation was the creation of the Critical Analysis Software or CAS for short. CAS was used on undergraduate Arts and Science curricula to teach students how to critically analyse what they had read.

CAS in fact was so successful that the University of ScotCan decided to make it available to a wider audience and offer it as a Distance Education course.

Your Task

You are part of the instructional design team who have been asked to redesign the software in order to make it suitable for delivery at a distance.

The software is currently used in a lab situation following a series of lectures where students are encouraged to interact with the professor and ask questions for clarification. CAS sets an exercise for the students to perform; this exercise is submitted and corrected by the professor in the traditional way. The professor also offers an open door policy to all students, encouraging them to drop by her office and discuss any problems they are having.

Your task is to work out a redesign for CAS; changing or adding any components that you feel are necessary to allow the software to be used in a distance education mode. Write down your ideas on the paper provided and roughly sketch any changes to the interface or screens of CAS.

You are free to ask the researcher any questions about the software, its usage or the task set. Please inform the researcher when you have completed your design. You will then be asked to describe your redesigns in your own words.

Figure 41 Critical Analysis Design Task Sheet

3. The subjects were then asked to fill out a short pre-questionnaire, figure 42, to inform the experimenter of their background and experience in designing instructional materials. The questions asked helped to support and substantiate whether designers in Higher Education use any formal design method. Complete results can be viewed in Appendix 2.

About You

- Name
- Background:

  e.g. Engineer, Languages etc.

- Have you designed any instructional material before, if so describe?

  e.g. paper-based materials, lecture software etc.

- If yes, do you use any particular method to produce your materials and if so describe it?
- If yes, is this method based on any educational theory?

Figure 42 Background Questionnaire.

4. The subjects were taken through screenshots, figures 43 and 44, of the Critical Analysis Software, viewed via a web browser. The original developer of the Critical Analysis Software prepared the screenshots. Screenshots were used to allow viewing of the software on any machine in any location. This was important since the experiments took place over two physical locations. The screenshots showed the key aspects of the software and the developer of the software provided some commentary below each screenshot, explaining what was happening in each scene.

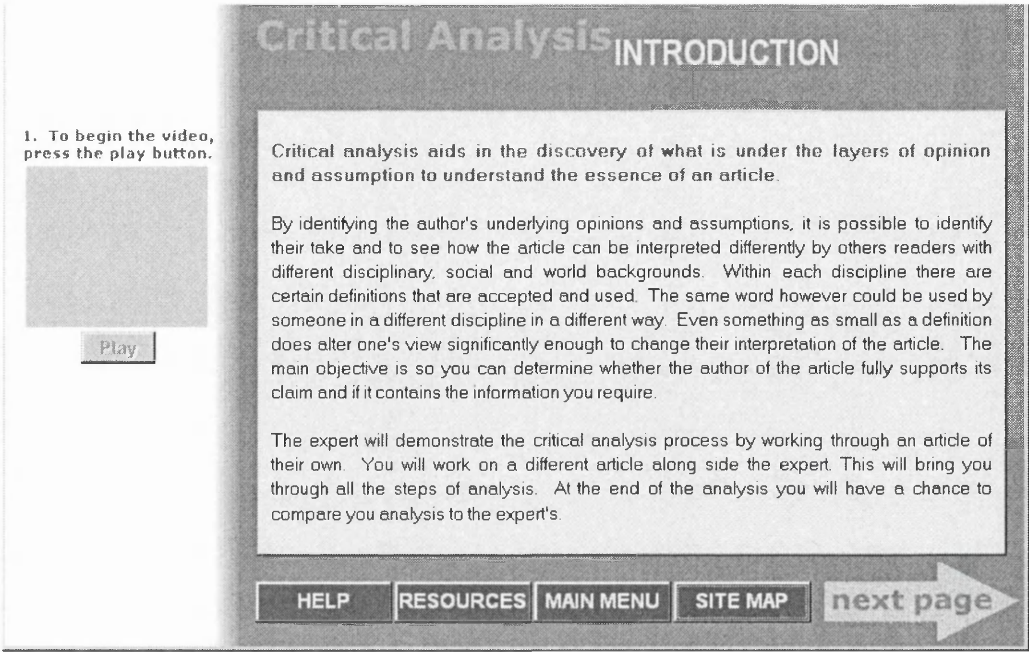


Figure 43 Screenshot from Critical Analysis Software.

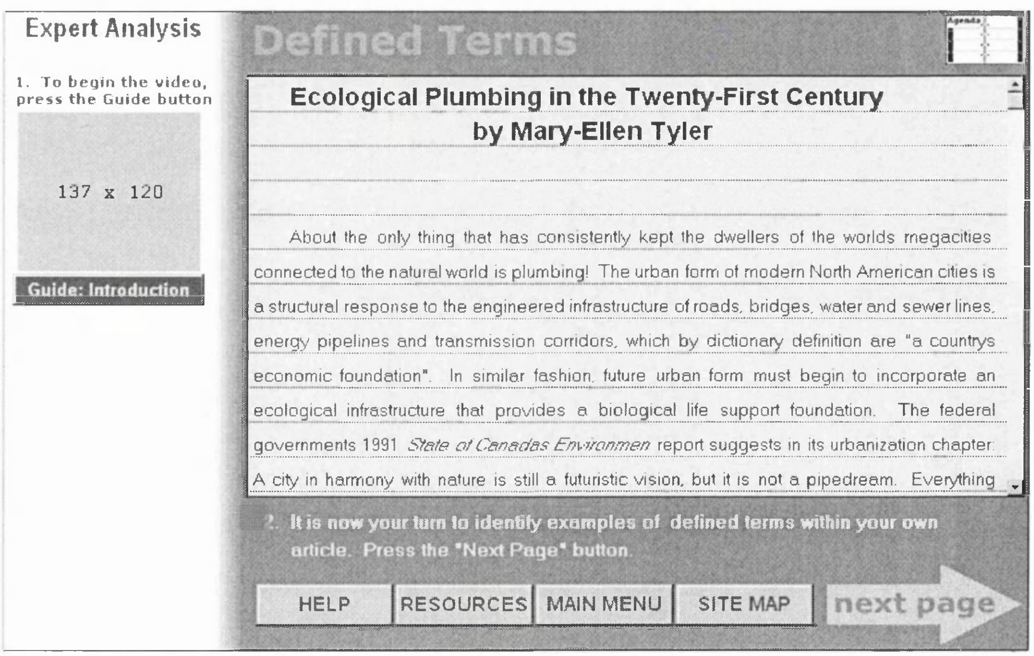


Figure 44 Screenshot from Critical Analysis Software.

5. The "with method" group were then taught the ABC method and given an Activity Implementation Chart, figure 45, of the current software design.

Conversational Analysis of CAS Software

Activity	Mode	Description
1	Human-Human	Teacher lectures to deliver main topics.
	Human-Computer	Computer uses video, text and graphics in CAS software to deliver material.
2	Human-Human	Students describe the conception of topic in lectures.
3	Human-Human	Teacher redescribes concepts in lectures.
4	Human-Human	Students redescribe their conception in the lectures.
5	Human-Computer	CAS software sets an essay to be critically analysed.
6	Human-Computer	Students perform the analysis on the material in software.
7	Human-Human	Teacher provides students with feedback by marking essay and discussing it.
	Human-Computer	Software gives students some useful guidelines to compare their essay with.
8	Human-Computer	Student may modify essay at any time in the program.
9	Human-Computer	Student is encouraged to reflect on their work and that of sample critical analyses.
10	Human-Computer	Student can make changes to analysis following reflection.
11	–	–
12	Human-Human	Teacher can modify lecture content based on the results of the evaluation of student essays.

Figure 45 Activity Implementation Chart for Critical Analysis Software.

6. Subjects were then allowed to read through the task once more and look to at the screenshots until they felt comfortable to begin the task.

7. The subjects were then asked to "think aloud" (Preece et al 1994) during their design. They were also provided with paper on which they could record the design. In the "think alouds" the subject was asked to say what

he or she is thinking about, what he or she is trying to do and why. The "think alouds" were audio-taped. When the subjects felt they had completed the task the audiotape was stopped and the observational study completed.

8. The subjects were then given a post-questionnaire to complete. The questionnaire can be viewed in Appendix 9.

5.3.6 Protocol Analysis

There are different methods of analysing observational data: process tracing, protocol analysis, interaction analysis, and conversation analysis. Sanderson & Fisher (1994) developed a framework to describe these different methods and refer to the methods collectively as "exploratory sequential data analysis" (ESDA).

"ESDA is any empirical undertaking seeking to analyse systems, environmental, and/or observational data (usually recorded) in which the sequential integrity of events has been preserved. The analysis of such data represents a quest for their meaning in relation to some research or design question..."

This study will use protocol analysis. Other empirical studies of design have used protocol analysis as a means to analyse the design process (Goel & Pirolli 1992, Guindon 1990). The audiotapes of all twenty subjects were transcribed into verbal protocols (Ericsson & Simon 1993). Verbal protocols are records of the subjects' spoken observations as they perform the design task set.

e.g. I need to first think about the platform this will run on.

e.g. I would make the video more interactive, allow the users to stop it when they want.

The spoken observations are broken into individual verbal protocols by deciding when a new idea or issue is being discussed. The above examples obviously relate to two different design issues and hence would be two individual verbal protocols. The example below, however, provides an example of an instance where there are a number of spoken observations but they all relate to the same design issue so would be one verbal protocol.

e.g. More help facilities are needed for the user. You could provide this easily by working out what people commonly asked about in the lab, the problem they discuss with their friends after the class.

To be able to test the hypothesis that use of the method had enhanced the design process, the verbal protocols are encoded in such a way as to allow the experimenter to see the range of topics in the design discussion.

5.3.7 Encoding the Protocol

The verbal protocols were coded firstly into three broad categories: Design Decision protocols, Design Related protocols and Unclassified protocols — figure 46. These categories will enable the design discussion to be broken down into broad design categories for further exploration. The experimenter wants to see when designers are actually making a design choice or decision – these are classified as 'Design Decisions'. Naturally, discussions related to design but not necessarily making a firm design decision, are made. These were classified as 'Design Related Protocols'. Any other discussions are not of interest to the experimenter in terms of validating the hypothesis. These discussions are categorised as 'Unclassified'.

Returning to the QOC studies of Maclean et al. for guidance, it was decided to follow their tried-and-tested further subdivision of the protocols — figure 46. The QOC is a general design method. The ABC design method is a CAL design method, a subclass of a general design model hence it is not unreasonable to follow the QOC subdivision of protocols. The names of these subdivisions were refined from the original names to be more suitable for this experiment. These subdivisions were called Statements, Questions, Alternatives, and Reasons This complete encoding is illustrated in figure 46.

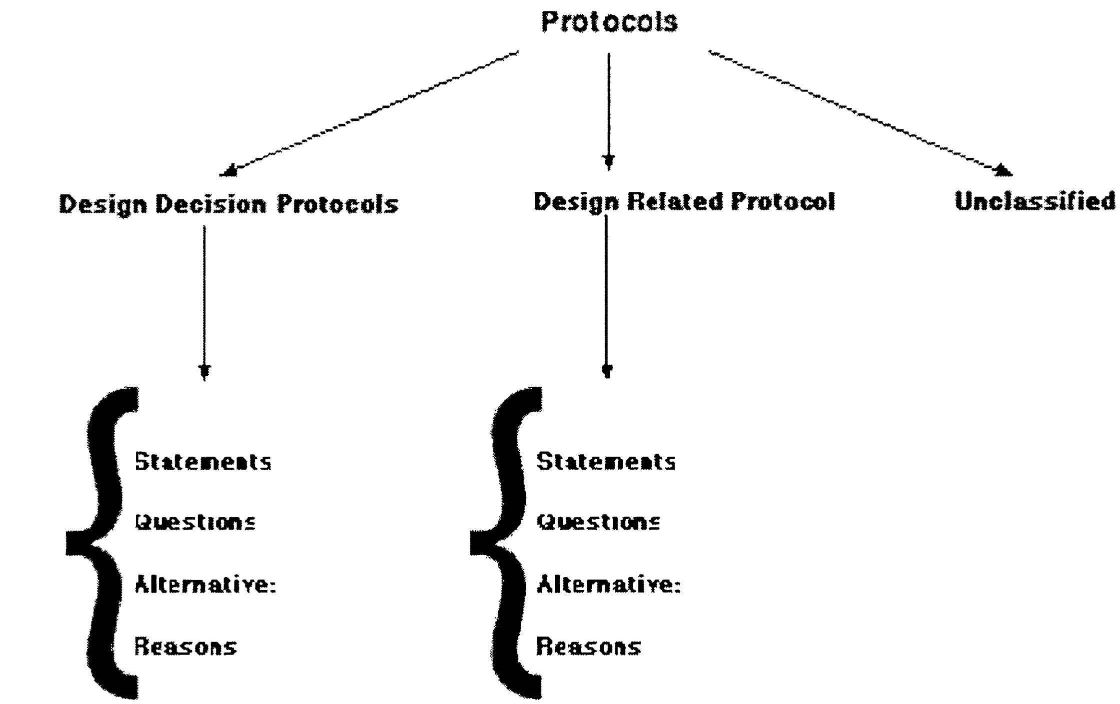


Figure 46 Protocol Classifications.

However, this subdivision of the protocols still does not provide enough information to accept or reject the hypothesis of the experiment i.e. that there are a greater number of pedagogical design discussions with use of the ABC method than in undirected design. Hence a further subdivision is required. Each of the four categories — Statements, Questions, Alternatives, and Reasons — can each be further subdivided into the levels of abstraction of the protocols: Objective, Pedagogical, Abstract, and Concrete. The subdivision is shown in figure 47.

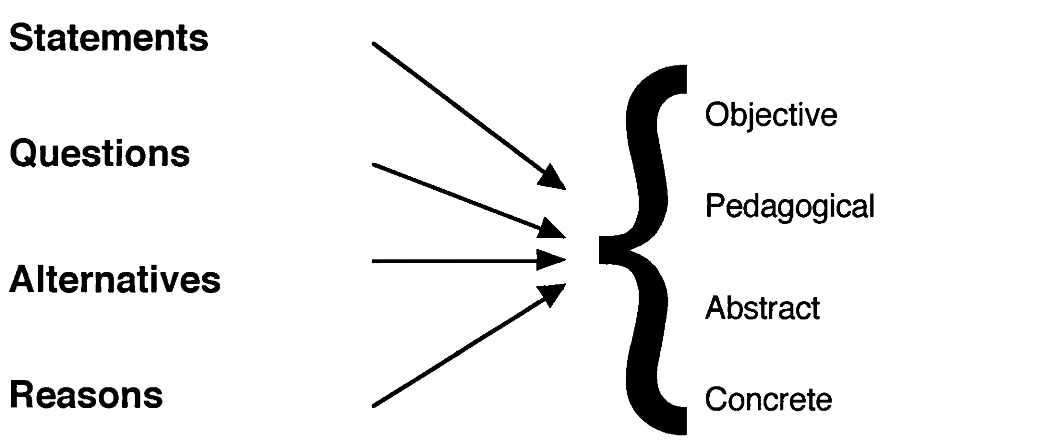


Figure 47 Further division of Protocols

The complete protocol category diagram can be seen in Appendix 3.

5.3.8 Detailed Protocol Classification.

Each of the categories at each level of the protocol analysis is now explained with the use of examples for each category. The examples given are for illustration only, they do not necessarily match discussions from subjects.

5.3.8.1 Design Decision Protocols (D)

These consist of protocols in which subjects are discussing actual design decisions, offering them as solutions for the instructional design task set.

Examples

I think I would say that it needs more help resources.

I would remove that menu and put in a list instead.

Email needs to be added to allow communication with the Tutor.

5.3.8.2 Design Related Protocols (R)

These consist of protocols in which subjects are discussing at the level above the actual design decisions. They are discussing design related issues but not actually offering anything as a solution to the design problem. Typically they might be criticising some aspect of the current system but not actually stating what should be done to correct it. Alternatively they may be providing a commentary on some aspect of the system.

Examples

I don't like that introductory screen in the software.

I think in distance education it is really important to be able to test yourself.

This menu at the bottom of the screen – it gives me the idea that it is a web page.

5.3.8.3 Unclassified (X)

These consist of protocols in which discussions do not fall into either of the above two categories. These discussions tend to be "throw away" statements not related to the design task set.

Examples

Its funny having someone looking over my shoulder

Can I write on this sheet?

Can you stop the tape until I blow my nose!

5.3.8.4 Statements (S)

These protocols are clear statements or assertions offered by the subject under either Design Decision or Design Related category.

Examples

I need to add more communication with student.

I don't like video clips in software.

More help resources are needed for the software.

5.3.8.5 Questions (Q)

These protocols ask questions in the two categories.

Examples

Hmm...should I include more help?

Can I assume they have email access?

What does this button do on this page of the software?

5.3.8.6 Alternatives (A)

These protocols consider a number of alternative solutions.

Examples

I could make it an email system or maybe via telephone would be good enough.

A pop-up list of options would be good – or maybe a series of buttons

This course could be delivered via the Web or through traditional paper-based distance learning materials.

5.3.8.7 Reasons (R)

These protocols discuss reason or reasoning for a particular decision.

Examples

I say provide hard copy notes because I wouldn't like to read all that text on the screen.

I say email because email would be faster than mailing in their papers by post.

More communication is needed because it is easy to feel isolated in distance learning.

5.3.8.8 Objective Level (O)

Protocols in this category are at the level of the aims and objectives of the course.

Examples

My objective is for the student to describe the main components of a Critical Analysis Essay.

I think the main aim of this course is teach them how to critically analyse a piece of written work.

5.3.8.9 Pedagogical Level (P)

Protocols in this category are discussing a high-level educational goal, or addressing some activity of the ABC method explicitly.

Examples

I need to provide more feedback for the students.

I need to think of ideas to encourage the student to be active about their learning.

Activity 5 is about setting task goals; the task goal would be in this case to write a summary.

5.3.8.10 Abstract (Ab)

These protocols are generally discussing the operational issues of higher-level discussions.

Examples

I could use email or telephone for communicating.

I think I would want to add in more options for the students.

I would make the entire course computer-based.

5.3.8.11 Concrete Level (C)

These protocols are discussions of low-level issues, such as software interface details or implementation details.

Examples

I need a button there to allow access to the email system.

That would need to be put in HTML.

I think the title should be on the right hand side of the screen.

5.3.8.12 Encoding Examples

To help understand the use of the protocol coding system, a worked example of the encoding is detailed below, using the following protocol abstract:

> In menu here, have a "ask question" box or something like that and the questions would be answered at the end of the day, every day by the lecturer

Figure 48 Example Protocol

First, the sentence is split up into two individual protocols.

> In menu here, I would add a "ask question" box or something like that

Figure 49 Example Protocol 1

> the questions would be answered at the end of the day, every day by the lecturer

Figure 50 Example Protocol 2

Beginning with Protocol 1: the first decision to make is which of the top-level categories this protocol falls into. The subject is saying what he or she would do, i.e. offering a solution, therefore this is a Design Decision item. Next we must decide what type of Design Decision it is. The subject is explicitly stating what he or she would do; therefore it is a Design Decision Statement. Lastly we must decide which level of abstraction this statement is at. The statement is discussing interface issues, this would indicate that it is at the Concrete level of abstraction. The entire protocol would be encoded as illustrated in figure 51.

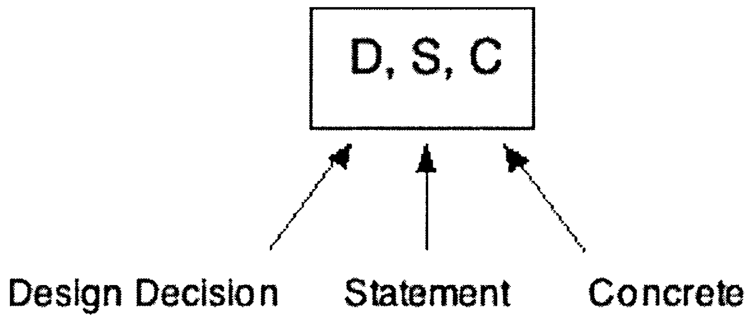


Figure 51 Protocol 1 encoded.

Now moving onto Protocol 2: again one must begin by deciding which top-level category the protocol falls into. This second protocol follows on from the first protocol, which we identified as being a Design Decision item; this protocol is still discussing the same item so this protocol would again be a Design Decision Item. The subject is again stating what would happen: therefore it is again a Design Decision Statement. This time the discussion is at an operational level, the subject is discussing how the questions would be answered, so this would fall under the Abstract category. The whole protocol would be encoded as shown in figure 52.

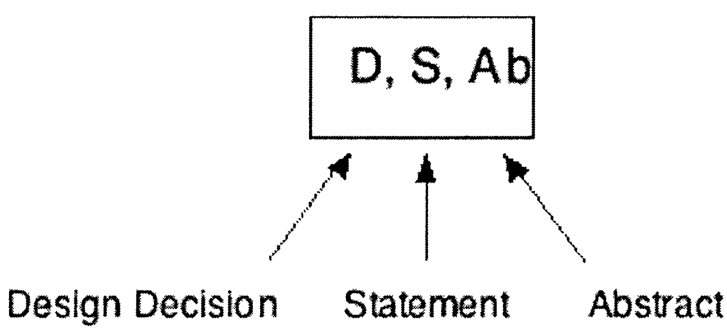


Figure 52 Protocol 2 encoded.

Let us take another encoding example:

Clearly these are good reflective exercises to help me identify my underlying incorrect assumptions.

Figure 53 Example Protocol.

This time there is only one sentence so there is no need to break it up any further. First we must decide if it is a Design Decision or a Design Related Item since it is clearly not a throwaway line, which would have made it Unclassified. The subject is commenting on a part of the course, which indicates that it is a Design Related Item rather than a Design Decision. The subject is stating his or her opinion on the current course so it is a Design Related Statement. This subject is discussing reflection which is a high level educational concept, therefore this Statement is at the Pedagogical level of abstraction. The complete coding is illustrated in figure 54.

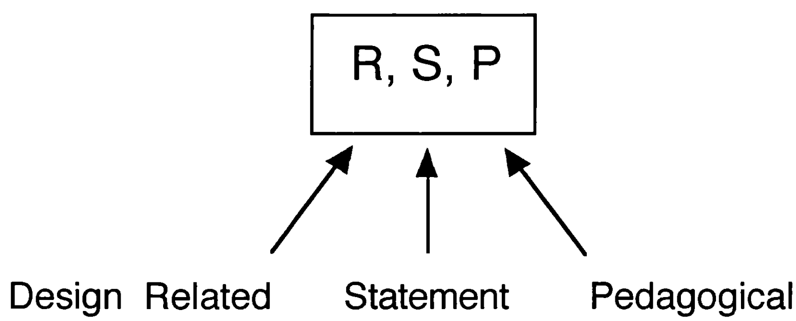


Figure 54 Example Protocol encoded.

5.4 Results of Experiment 1

5.4.1 Broad Stroke Results

Before taking a look at the detail required to answer the hypothesis set for the experiment, it is interesting to look at a more high-level view of the data, these are referred to here as the Broad Stroke Results.

By looking at the distribution of protocols across the three top-level protocol categories (Design Decision Items, Design Related Items and Unclassified Items), under the two conditions of the independent variable, it is possible to identify the effect the method has had on the design process. In order to check for potential bias in the researcher's coding of the protocols, a number of transcripts were given to an independent evaluator (Dr Mark Dunlop, University of Strathclyde) who also coded the transcripts. This coding was then compared with that of the researcher. The coding closely matched that of the independent evaluator.

The raw counts for each category were normalised by converting the raw counts for each protocol category to percentages. Data are presented as a percentage of the total number of discussion items. Each row in figure 55 and 56 represents the results for one subject.

"With Method" Results

Design Decision Items	Design Related Items	Unclassified Items
84.7%	11.9%	3.4%
84.8%	12.2%	3.0%
62.5%	32.5%	5.0%
76.5%	23.5%	0.0%
72.4%	25.9%	1.7%
64.5%	33.3%	2.2%
69.8%	26.8%	3.4%
81.7%	15.1%	3.2%
23.2%	69.8%	7.0%
0.0%	0.0%	0.0%

Figure 55 Broad Stroke Category Split of Protocols with use of ABC Method

N.B. The last subject of the experiment, the results appear in the final row of the above table, did not believe that distance learning was a valid teaching method and did not believe he was able to redesign the course and consequently no data was collected for him.

"No Method" Results

Design Decision Items	Design Related Items	Unclassified Items
51.8%	47.3%	0.9%
70.2%	25.5%	4.3%
70.3%	24.3%	5.4%
67.9%	30.2%	1.9%
51.9%	48.1%	0.0%
35.2%	63.9%	0.9%
60.3%	36.8%	2.9%
53.1%	46.9%	0.0%
54.1%	45.9%	0.0%
20.0%	66.0%	14.0%

Figure 56 Broad Stroke Category Split of Protocols with use of undirected design.

Illustrating the raw data shows the difference between the two groups more clearly, as illustrated in figures 57 and 58.

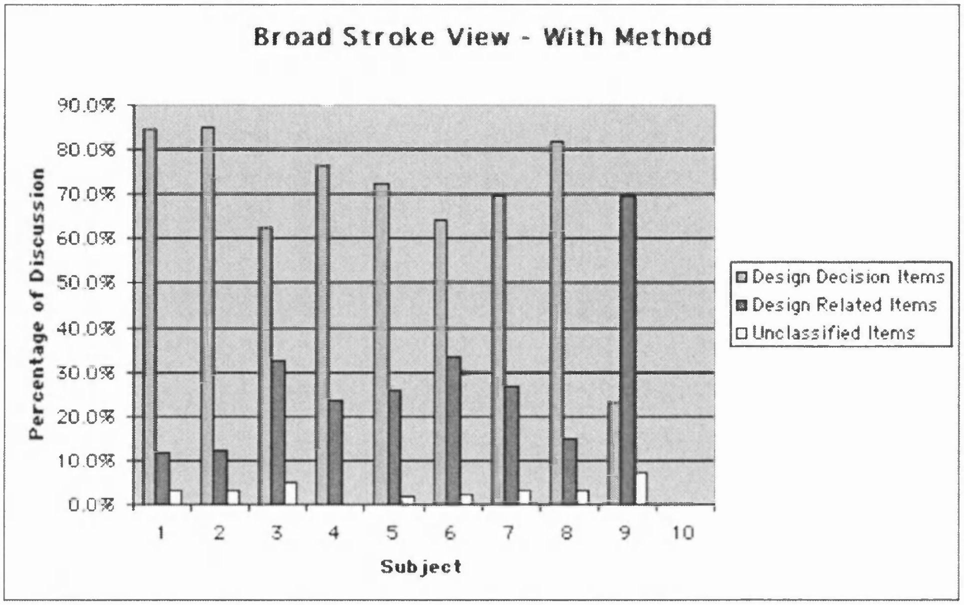


Figure 57 "with method" – Experimental results illustrated

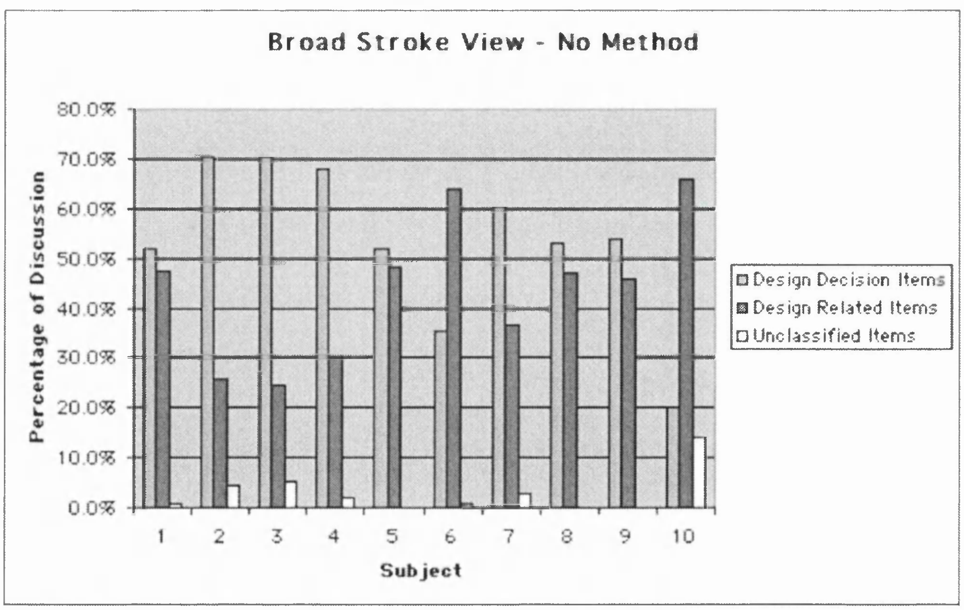


Figure 58 "no method" – Experimental results illustrated

It can be seen from the graphs that the majority of the discussion consisted of Design Decision protocol items for both groups of subjects. It is also noticeable that the number of Design Decision Items is higher in the "With Method" group (Average Design Decision Items With Method is 61%, Average Design Decision Items No Method is 53%). The number of Design Related Items is clearly greater in the "No Method" Group (Average Design Related Items With Method is 26%, Average Design Related Items No Method is 43%). This suggests that the "With Method" group's discussions were more focussed on providing actual design solutions to the problem set. Compare this with the "No Method" group who spent a great deal more time discussing, critiquing and commenting on the problem than offering actual solutions. It could be argued that the use of the new Design Method has focussed the attention of the subjects on producing important design solutions.

5.4.2 Fine Stroke Results

It is now time to look at the data in more detail in order to answer the hypothesis set in Section 5.3.1. Looking at the Design Decisions category and its subcategories in detail should highlight any further differences in the two groups. The raw data is shown in figure 59 and 61. The graphs — figures 60 and 62 — illustrate the spread over the four sub categories: Statements, Questions, Alternatives, and Reasons.

Statements	Questions	Alternatives	Reasons
84.5%	5.2%	6.9%	3.4%
54.6%	21.2%	12.1%	12.1%
80.8%	3.9%	0.0%	15.3%
80.6%	19.4%	0.0%	0.0%
75.0%	0.0%	7.1%	17.9%
86.0%	0.0%	4.7%	9.3%
87.8%	2.4%	3.7%	6.1%
80.7%	0.0%	9.6%	9.7%
62.5%	32.5%	2.5%	2.5%
95.0%	0.0%	5.0%	0.0%

Figure 59 "No method" design category spread raw data results

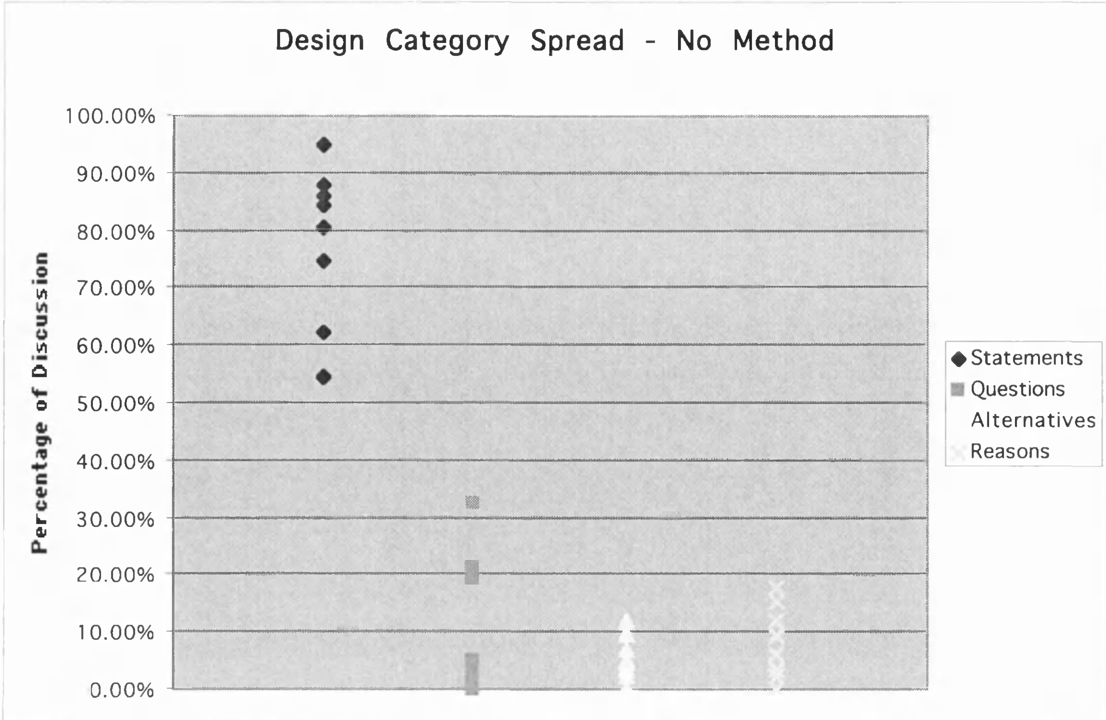


Figure 60 *Design Category Spread – "no method"*

The figure 60 shows that most of the discussion was spent making design statements (55-95%). The rest of the discussion was split between the participants asking design questions, exploring alternatives and reasoning about their design.

Statements	Questions	Alternatives	Reasons
68.0%	6.0%	0.0%	26.0%
100.0%	0.0%	0.0%	0.0%
80.0%	0.0%	0.0%	20.0%
84.6%	2.6%	0.00%	12.8%
88.1%	0.0%	4.8%	7.1%
89.7%	0.00%	3.4%	6.9%
78.9%	6.7%	4.8%	9.6%
73.7%	17.1%	1.3%	7.9%
87.9%	3.0%	3.0%	6.1%

Figure 61 *"With method" design category spread raw data*

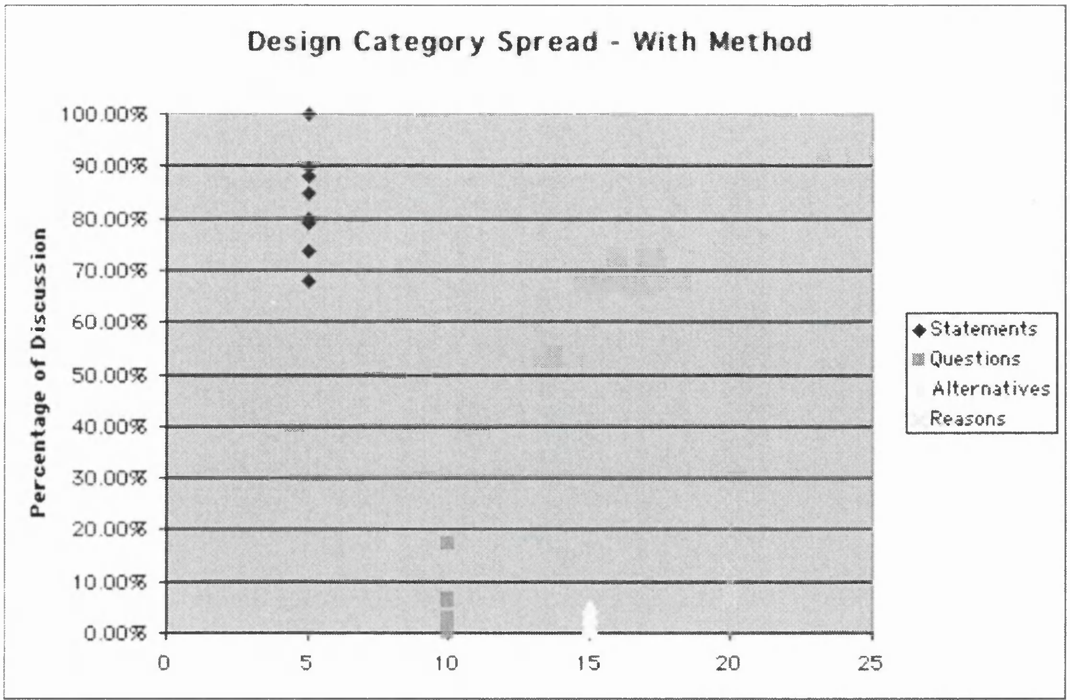


Figure 62 Design Category Spread – "with method"

The two graphs do not show any significant difference across the categories. In the 'with method' Design Category Spread 68-100% of the discussion was spent on making design statements compared to 55-95% in the 'no method' Design Category Spread. It had been expected that the 'with method' results would have resulted in significantly more design statements being made. Since the raw data does not show this it is necessary to go further down the encoding protocol, to look at the level of abstraction the protocols are at i.e. the types of design statements that were made before we can accept or reject the hypothesis.

Let us consider the hypothesis we are trying to accept or reject:

The dependent variable, i.e. the number of pedagogical design discussion items will be greater with the use of the ABC method than in undirected design.

Figure 63 shows the percentages of the pedagogic discussion under the two independent variable conditions.

With Method Pedagogic Items	No Method Pedagogic Items
48%	35%
61%	22%
48%	4%
66%	11%
6%	22%
45%	12%
18 %	7%
37%	0%
30%	10%
0%	10%

Figure 63 *Comparison table of the number Pedagogic Design Items under the two conditions of the independent variable.*

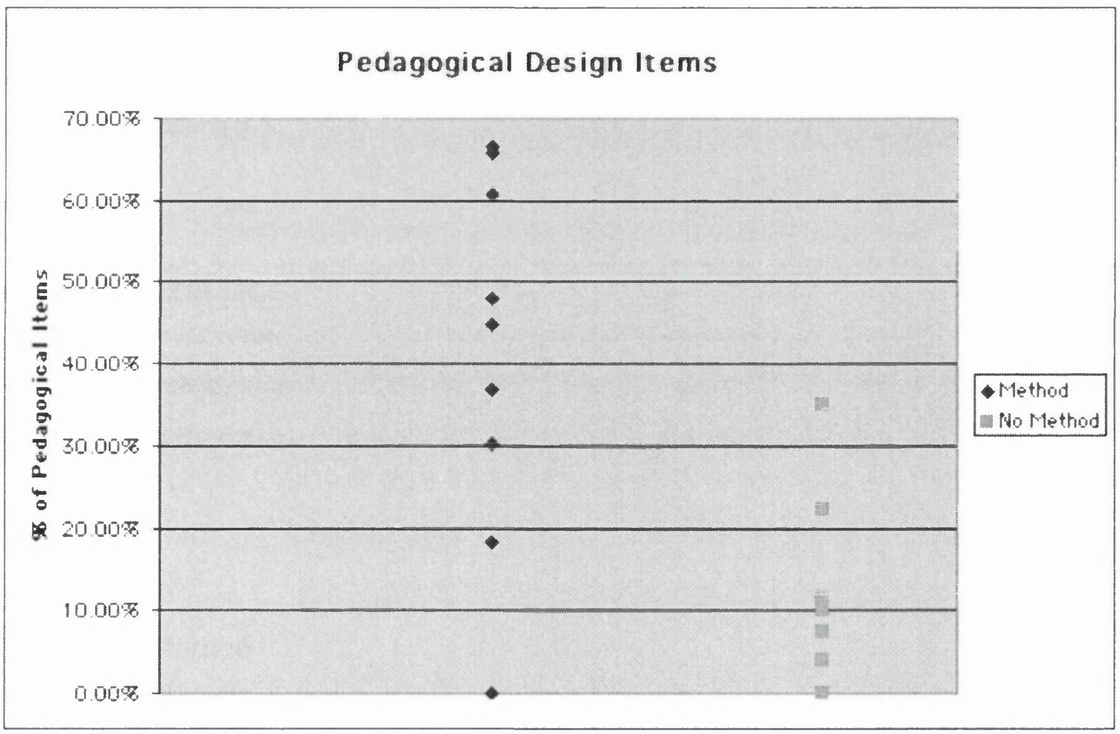


Figure 64 *Percentage of Pedagogic Design Items illustrated.*

Figure 64 clearly shows that there are more Pedagogic discussion items under the "with method" condition (Average number of Pedagogic items with method is 41%, Average number of Pedagogic items with no method is 13%). Therefore we are able to say that the independent variable has produced a difference in the variance of the two sets of data.

In order to confirm the difference that the ABC Method made to the pedagogic design discussion items, the parametric t-test was applied since it is particularly useful when small data sets are involved. The t-test was applied using the normal 5 percent ($p=0.05$) level of significance and the stricter 1 percent ($p=0.01$) (See Appendix 4 for full statistical analysis). Both values resulted in a significant result ($t=2.92$) i.e.We can accept the hypothesis that the number of pedagogical design discussion items is greater with use of the ABC Method.

5.4.3 Conclusion

Experiment one has shown that use of the ABC method has produced a significant difference in the number of pedagogic design items discussed when compared with undirected design. However, one might argue that it is not surprising that application of *some* systematic method made some difference to the design. Application of any method may have produced a difference between the groups. In order to show that the ABC method is better than other methods, a second comparative experiment was needed, described in Section 5.5.

5.5 Experimental Design: Experiment 2

Experiment 2 was created to show that the differences found in collected data were due to the new method, and not just the use of any structured design method. In order to show such a difference a comparative study with an alternative design method was undertaken.

5.5.1 Alternative Method

First it was necessary to find a suitable method to perform the study. A method called "The Systems Approach to course and curriculum design", developed by the Scottish Central Institutions Committee for Educational Development (CICED 1990) was chosen because it is aimed at a similar target audience i.e. Higher Education developers, and presented in a similar format to the new method. The full CICED method can be found in Appendix 5. The Systems Method was actively given out to Higher Education academics by Paisley University Education Unit when the Unit was approached by academics who were looking for guidance to develop instructional materials.

5.5.2 Introduction

The independent variable in this evaluation experiment is the design method used. We are interested in two levels of the independent variable in our experimental design: the ABC method and the Systems method. The dependent variable is the number of pedagogic issues that the designer produces. This experiment investigates the claim that the ABC method is better than the Systems method.

5.5.3 Hypothesis for Experiment 2

The dependent variable i.e. the number of pedagogic design items that the designer produces will be greater with use of the ABC Method than with the Systems Method.

5.5.4 Subjects

Two groups of subjects were used, to match the number of levels in the independent variable that we were interested in: one group was trained in the ABC design method, the other group was trained in the Systems method. Each group was then given the same design task. An independent groups design was used where subjects were randomly assigned to each group. Twenty subjects participated in the experiments. In this second experiment the subjects were research assistants and postgraduate students from Glasgow University Computing Science department. Again, subjects were engaged at Higher Education at some level, and had skills typical of novice designers.

5.5.5 Design Task

Discussion in Section 5.3.3 for Experiment 1 indicated the difficulty of choosing a suitable design task. A considerable amount of time was devoted to searching for a second academic topic, suitable for a short design experiment and satisfying the conversational framework's two-level view of knowledge. After much consideration this search was abandoned in favour of a general non-academic topic that the subjects could relate to and handle in a short design experiment. The topic chosen was the prevention of VDU (Visual Display Unit) hazards. The justification for allowing such a topic was that although Laurillard's conversational framework is focused at Higher Education in particular, it has wider applications. Also the constructivist traditions that the framework grew out of originated not in Higher Education but in child development (Piaget 1970).

5.5.6 Operationalising the experiment

The procedure for each experiment is now described:

1. Each subject was assigned to one of the two groups representing the two levels of independent variable. The subjects were assigned alternately to the two groups in the order they responded to an email call for volunteers. The Systems method was referred to as Method A and the ABC method referred to as Method B.

2. The subjects were trained in the appropriate method and given 5 minutes to read through the method documents provided. See Appendices 1 & 2. Training involved the experimenter explaining the method and illustrating use of the method with an example.

3. They were then shown the task as described in figure 65.

Design of VDU Instructional Materials

Your Task

You have been drafted onto a design team that has been asked to produce new training materials to fit into a new Health & Safety campaign that the University is running.

Your team has been tasked with producing instructional materials to teach staff methods for preventing VDU hazards.

Following the design method that you have been shown, write down 10 design items that you consider to be important for this design task.

You have 10 minutes to complete this task.

Figure 65 VDU Design Task sheet

4. The subjects were then asked to fill out a short pre-questionnaire — figure 66 — to inform the experimenter of their background and experience in designing instructional materials. The results of this questionnaire can be seen in Appendix 6.

About You

- Name

- Background:

  e.g. Engineer, Languages etc.

- Have you designed any instructional material before, if so describe?

  e.g. paper-based materials, lecture, software etc.

- If yes, do you use any particular method to produce your materials and if so describe it?

- If yes, is this method based on any educational theory?

Figure 66 Background questionnaire.

5. The subjects were given written VDU Materials, as illustrated in figures 67 and 68 and given 5 minutes to read through them.

CHAPTER NINE

VDU hazards and their prevention

Nearly 10 million visual display units (VDUs) are in use in the UK. In some workplaces, computerisation has taken place virtually overnight, with little thought for its impact on working methods. The new technology has brought enormous benefits to businesses, but there is also concern that the paperless office might be hazardous to health.

Repetitive strain injury (RSI) or work-related upper limb disorder (WRULD) is one potential problem (see Chapter 8) and others are discussed below. Some of the adverse effects are unique to the technology, while others are related to the pace of work, the concentration required and prolonged work in a fairly static position.

Figure 67 VDU background materials

Surviving at work

PREVENTING PROBLEMS

Computers should not be introduced where tasks are already being done perfectly well without them. As Bert Lance said, "If it ain't broke, don't fix it".

Mastering a personal computer should include learning to sit at the terminal as well as how to use the software, but it rarely does. The employer has responsibility for reducing the risk from VDU work, although some things you have to do for yourself. See how many of the following measures you can put into action.

- Your chair should be adjustable for height and the back rest for height and tilt. The back rest should give support in the lumbar area (the small of the back), though it should not exaggerate the normal curve of the spine.
- Your chair should tilt slightly forwards, about 5 degrees from the horizontal.
- You should sit symmetrically, facing the keyboard and the screen. Normally, the greater the number of hours spent at a VDU, the greater the risk, but occasional users are sometimes at disproportionate risk because they relegate the keyboard to an unused corner of the desk, and then have to twist to reach it.
- Back, neck and arm symptoms are fewer if the elbows are at 90 degrees and the upper arms vertical when using the keyboard.
- If you have a lot of copy-typing to do, a document holder helps minimise awkward neck movements.
- The desk surface should be large enough, with space to accommodate your forearms in front of the keyboard. The edge of the desk should be smooth.
- There should be enough desk clearance for your thighs, legs and feet.

62

VDU hazards and their prevention

- Your legs should not dangle. If you are short, you may need a footrest. If you ask for one, your employer must provide it.
- The screen should be separate from the keyboard, and be able to tilt and swivel to suit the user. You should be able to draw a horizontal line between the top edge of the screen and your eyes. Monitor arms are ideal for positioning the screen, but telephone books are better than nothing. Laptop users may find it impossible to get good positioning for the eyes and arms at the same time.
- The screen should be about 60 cm away from your eyes, but this also depends on your eyesight and what is being displayed on the monitor.
- There should be no visible flicker or glare from the screen. Anti-glare attachments are not essential since glare can usually be eliminated with good positioning, at right angles to the window or the strongest light.
- Use a good keyboard technique, touch typing rather than jabbing with one or two fingers.
- Avoid holding the phone between your ear and shoulder and using the VDU at the same time.
- Not everything may yet be known about new technology, so report any adverse effects, whether or not you think they are related to the VDU.

Breaks

However good the workstation and however expert your technique, sitting at the terminal is hard work both mentally and physically. Ideally, no more than half your working day should be at the keyboard.

Breaks should be the order of the day, and taken before fatigue sets in. Short frequent breaks are better than long occasional ones, and are best taken away from the desk, for

63

Figure 68 VDU background materials

6. The subjects were then asked to write down up to 10 design items for the design task set, on a prepared sheet. They were told when 5 minutes had passed.

7. The subjects were then asked to categorise their design items according to the following set of categories in figure 69.

Design of VDU Instructional Materials

Categories : Design Items can fall into the following categories:

Objective – items stating aims and objectives of the materials

Pedagogical – items trying to perform some higher order teaching and learning activity

Abstract – items that are dealing with the operationalising of items often expressed in the Pedagogical category

Concrete – items dealing with interface issues or other real/concrete issues e.g. hardware, networking etc

Mix – items that fall into more than one of the above categories

Examples

"design an interface with a button and menu" – Concrete

"need a computer with at least 64Mb of RAM" – Concrete

"think about delivery of material e.g. web based or book" – Abstract

"I would use email to set an exercise for staff" – Abstract

"Use graphics to deliver main concepts" – Pedagogical

"set some exercise for the staff to try out" – Pedagogical

"provide feedback to staff on how they performed in exercise" – Pedagogical

"the objective of this exercise is to help prevent hazards" – Objective

Figure 69 VDU Classification system.

The original purpose in getting the subjects to perform the analysis on the design item data was to speed up the post-experiment analysis stage, since considerable time had been spent on this in Experiment 1. However, after looking at the data and categorisation it was clear that there was too much variation between subjects in their use of the categories. So, for consistency, the researcher repeated the categorisation.

5.5.7 Validating Categorisation

In order to validate the categorisation undertaken by the experimenter and check for potential bias, an independent evaluator (Andrea Chappell, University of Waterloo, Ontario) was asked to categorise the design discussions made by the subjects. The independent evaluator's categorisation matched the experimenter's in all but two statements. In these two cases the evaluator considered that the design discussion to cover two categories and not just the one categorised by the experimenter. Overall this meant that the categorisation was the same as the experimenter and no bias was found.

5.6 Results of Experiment 2

We begin by looking at the spread of the categories under Method A (Systems Approach Method.) Again each row of figures 70 and 71 represents the results for one subject.

It should be noted that some of the subjects did not produce the 10 items asked for within the time limit.

Subject	Objective	Pedagogical	Abstract	Concrete	No. Items	Avg. Items
1	4	0	3	1	8	8.6
2	0	0	6	0	6	
3	0	3	4	1	8	
4	4	0	6	0	10	
5	1	2	6	0	9	
6	3	3	3	0	9	
7	1	2	6	0	9	
8	0	2	7	1	10	
9	0	1	6	1	8	
10	1	2	6	0	9	

Figure 70 Results of Experiment 2 raw data Discussion Items produced under use of the Systems Method

Objective	Pedagogical	Abstract	Concrete
50.0%	0.0%	37.5%	12.5%
0.0%	0.0%	100.0%	0.0%
0.0%	37.5%	50.0%	12.5%
40.0%	0.0%	60.0%	0.0%
11.1%	22.2%	66.7%	0.0%
33.3%	33.3%	33.3%	0.0%
11.1%	22.2%	66.7%	0.0%
0.0%	20.0%	70.0%	10.0%
0.0%	12.5%	75.0%	12.5%
11.1%	22.2%	66.7%	0.0%

Figure 71 Results of Experiment 2 normalised Discussion Items produced under use of the Systems Method

These raw data results are illustrated graphically in figure 72.

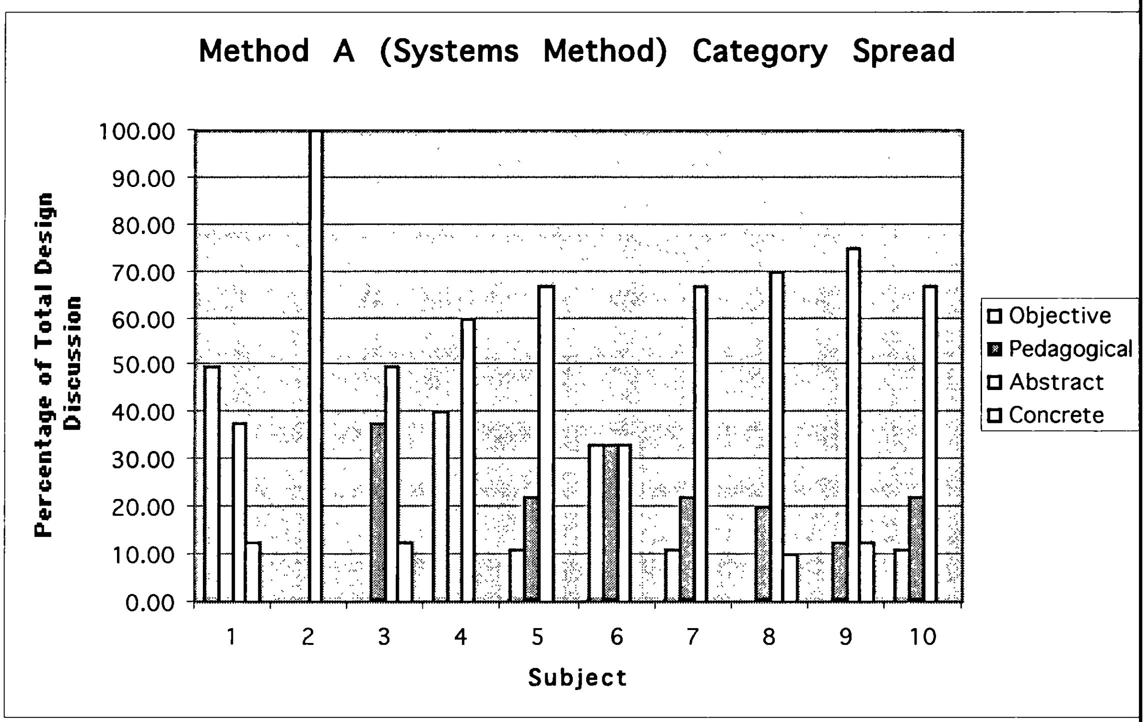


Figure 72 Method A Systems Method Discussion Category Spread

The raw data results for experiment 2 using ABC method are shown in figures 73 and 74.

Subject	Objective	Pedagogical	Abstract	Concrete	No. Items	Avg. Items
1	0	6	0	0	6	7.6
2	0	4	3	0	7	
3	0	9	1	0	10	
4	0	7	0	0	7	
5	1	2	6	0	9	
6	1	9	0	0	10	
7	1	8	0	0	9	
8	1	4	0	0	5	
9	1	5	1	0	7	
10	2	3	1	0	6	

Figure 73 *Raw data results from experiment 2 using ABC method.*

Subject	Objective	Pedagogical	Abstract	Concrete
1	0%	100%	0%	0%
2	0%	57%	43%	0%
3	0%	90%	10%	0%
4	0%	100%	0%	0%
5	11%	22%	67%	0%
6	10%	90%	0%	0%
7	11%	89%	0%	0%
8	20%	80%	0%	0%
9	14%	72%	14%	0%
10	33%	50%	17%	0%

Figure 74 *Raw data normalised results from experiment 2 using ABC method.*

These raw data results are illustrated graphically in figure 75.

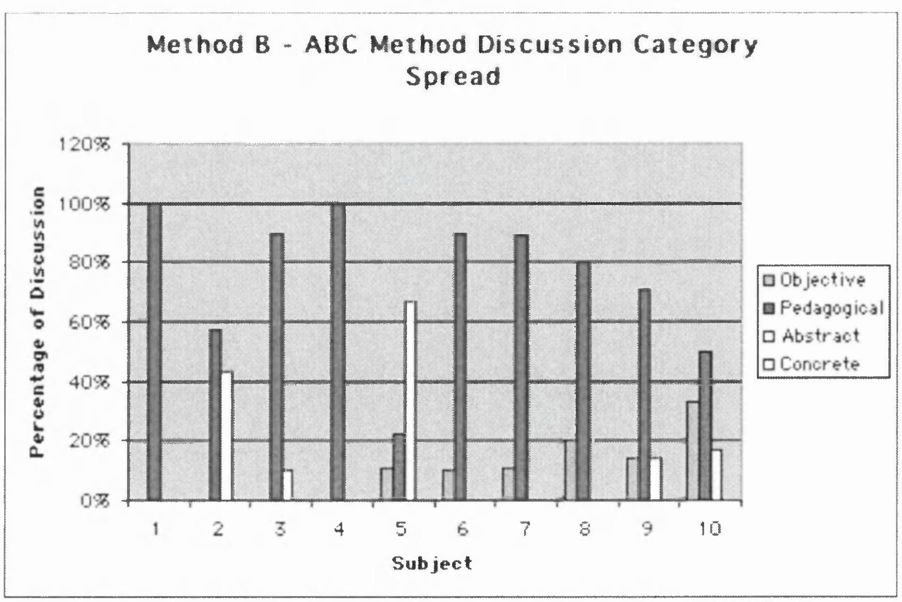


Figure 75 *Method B ABC Method Discussion Category Spread*

The average number of design items that the subjects produced using the Systems Approach was 8.6 items. This was higher than in the ABC method case that produced an average of 7.6 design items. The difference in the two methods can be seen in the percentages of the design items under the categories, as illustrated in figure 76.

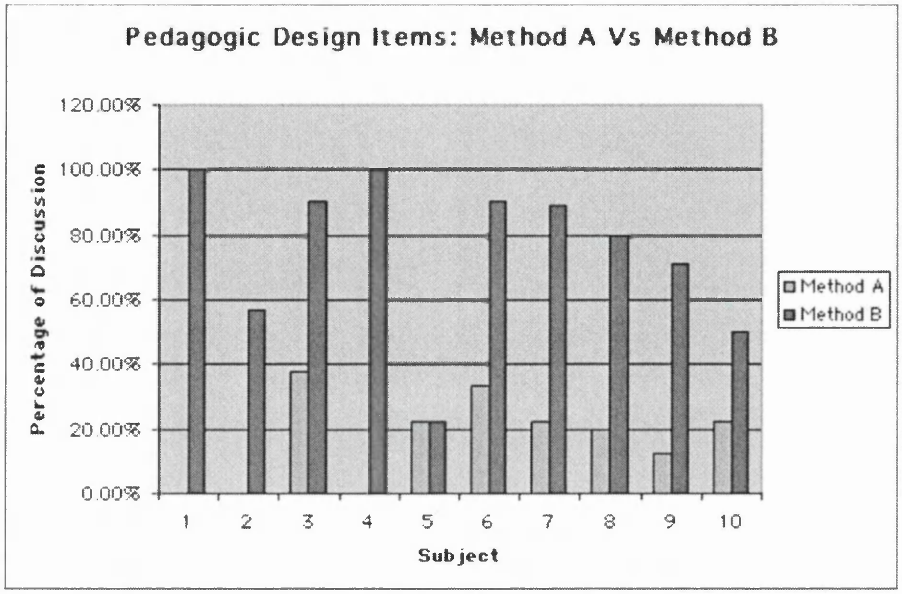


Figure 76 Pedagogic Design Items: Method A Vs Method B

The ABC method (Method B) has a clearly visible higher proportion of Pedagogic design items. The Systems method has the higher proportion of design items in the Abstract category. The Systems Approach also has a significant number in the Objective Category.

The purpose of this second experiment was to reject or accept the hypothesis that the number of pedagogic design items discussed would be greater with the ABC method than with the Systems Method.

The graph above clearly shows that there are more Pedagogic discussion items under the use of the ABC method. Assuming that the data has come from a normal distribution and the independent variable has produced a difference in the variance of the two sets of data, under these assumptions, it is suitable to apply parametric statistical tests since the data follows the necessary conditions (Miller 1996).

The parametric t-test was applied since it is particularly useful when small data sets are involved. The t-test was applied using the normal 5 percent ($p=0.05$) level of significance. (See Appendix 7 for full statistical analysis).

5.6.1 Conclusion

The resulting value in t (t=6.40, p=0.05) is statistically significant. This would indicate that the ABC method had indeed made a positive difference to the design process, producing more pedagogical design items and that it was not just *any* method that had produced the results in Experiment 1.

5.7 Other Evaluations Performed

The ABC Design Method was also used by another researcher to design and develop CAL materials. This provides evidence that the ABC method is usable by other designers. Mathers (1998) used the ABC Design Method to design and develop CAL materials for Strathclyde Fire Brigade:

> *"In 1991, Strathclyde Fire Brigade introduced lectures as a means of training firefighters. At first the firefighters enjoyed this new type of training, but after some years of receiving the same lectures, they became tired of their repetitive nature. Strathclyde Fire Brigade view the solution to this problem as a series of CAL packages." (Mathers 1998)*

Firefighting is not an academic subject but, as stated earlier, it is believed that Laurillard's Conversational Framework has wider applications. Also, when we examine the teaching and learning of the firefighters, we find that it falls into two distinct types similar to those seen in the academic world:

Technical Training Sessions – these consist mainly of lectures on theory, delivered during nightshift by the Training Officer

Practical Training Sessions – these consist mainly of drill practices.

These sessions seem to match the level of descriptions and level of actions in the Conversational Framework. Despite Mathers recognising that it is important to link the two levels of teaching and learning (Mathers 1998, p37), he applies the Conversational Framework separately to each type of training independently and does not consider them as a whole educational experience. This may indicate that it is not explicit in the ABC method how to apply the framework and generate the resulting Activity Implementation Charts.

5.7.1 Results of Mathers Evaluation

Despite applying the Conversational Framework independently to the types of training in the firefighting context, Mathers did find gaps in the training when the Activity Implementation Charts were examined. (For full charts, see Appendix 11) In the Technical Learning Cycle he found that there was no feedback from the firefighters to the training department that kept the lectures up-to-date. He noted that this was a serious problem. This was supported by responses to questionnaires given to the firefighters: the firefighters reported that they found the current training process very repetitive and the lectures to be the least effective method of training. In the Practical Learning cycle, examination of the Activity Implementation Charts again highlighted lack of feedback from the firefighters to the firefighter officials in charge of training.

Mathers reported that using the ABC Design Method had been useful and helped to highlight issues that were necessary to address e.g. gaps in the Activity Implementation Chart helped to highlight weaknesses in the supported learning.

Mathers also reported problems in the use of the method in the firefighter training context:

1. Firefighter training separates the learning done at the Level of Descriptions and that done at the Level of Actions, and Mathers stated he found it difficult to completely decouple the teaching and learning done at the two levels in the ABC method.

2. The ABC Design Method did not highlight what were the most important Activities e.g. if Activity one was weakly supported this would have a knock on effect on the rest of the teaching and learning experience.

3. Mathers reported that the ABC Design method did not take account of learners' individual learning styles.

5.7.2 Comments on Mathers' Evaluation

The ABC Design method was created with the explicit aim of addressing the needs for such a design method in Higher Education, as discussed in section 2.4.3.1. Problem (1) is due to Mather's incorrect application of the Conversational Framework as discussed in section 5.7.1 Problem (2) seems an important point. It may be worth highlighting the critical activities in the teaching and learning setting, particularly for inexperienced CAL designers and users of the method. This would allow them to focus their time and resources on the most important activities first. Problem (3) will be discussed in Chapter 6.

5.7.3 Ross Evaluation

Ross (1999) used the ABC Method (then known as the Practical Design Method) to design web-based CAL materials for Oxfam to train volunteers.

> *"The training of volunteers is deemed beneficial for three reasons. Firstly, training helps volunteers to successfully fulfil their role brief...they are often asked questions about Oxfam, its aims, where the money goes...Training is also regarded as an influential factor in the motivation and development of volunteers. Thirdly, training is considered important to enable volunteers to make wider contribution to the organisation."*

Ross's solution was to develop stand-alone web-based courses. Ross used the ABC Method to design these materials. An extract from her Activity Implementation chart is illustrated below.

Design Rationale for Introduction To Oxfam Module   Appendix D

Practical Design Method - Activity Implementation

Title : Introduction to Oxfam

Aim : 1 Increase knowledge of Oxfam

Objective : 1.a) Identify Oxfam's main activities and their contribution to the overall aims.

Activity Number	Teaching Mode (H-H, H-C, Other)	Description
1.	Other H-H. Other H-C; H-C; Text	Previous knowledge; induction and briefings, slide show; videos; graphic chart of activities online information; and printed information; "Have a look at the "This Is Oxfam" Leaflet, or use your existing knowledge to answer these questions about what Oxfam does"
2.	H-C	Activities Quiz: name activities (multiple text input) match them to aims (MC) match to a level of action (MC)
3.	H C	Give hints for wrong answers
4	H C	Try again to answer quiz
5.	H-C	Volunteer Role Quiz: "What is your role?" (MC) "To which aims does your role contribute?" (MC) "How does it contribute?" (short answer) "At what level?" (MC)
6.	H-C	Answer quiz
7.	H C	Give canned hints – "think about..." Canned answers
8	H C	Redo answers
9	H-C	Student is prompted to reflect on their practical role within Oxfam's activities and changes their answers to Q2
10	H-C	Student thinks about their role in view of the wider range of activities and adapts their answers for Q 5.
11	H-C	Teacher rewrites Q5 in view of students' answers
12.	H C	Teacher rewrites Q2 in view of students' answers

Claire Ross   vi
Appendices Draft 1. 09/03/99

Figure 77 Ross Activity Implementation Chart

Following CAL implementation Ross returned to the ABC method to perform essential evaluation of the materials produced. (See Appendix 12 for completed evaluation templates). Ross found use of the ABC method evaluation template focussed design on producing learning activities that would promote learning and also highlighted areas that required redesign:

> *"A 'walk-through' of the Practical Design Method, revealed significant shortcomings in the design of learning activities. A much more comprehensive approach was required to ensure all twelve learning activities were covered... Activities that encouraged more practical activities or at least connection of the*

concept to students' own personal experience had to be created...The encouragement of reflection both on the concept and on activities was needed..." *p20*

Ross also noted that having a record of the design rationale clearly aided maintenance of the designed course. This would allow future designers to examine the reasons behind the current design.

5.7.4 Comments on Ross Evaluation

Ross appears to have used the ABC method as the researcher intended. The intended benefits of use of the ABC Method were highlighted in Ross's evaluation e.g. focus design on creating activities that promote learning, focus on areas for redesign and the benefits of having a documented design process. This evaluation encouraged the researcher that the ABC Method was indeed beneficial to designers and was clearly presented in a way that they could easily access and use.

5.8 Summary

The aim of this chapter was to test the hypothesis that the ABC design method enhnanced the CAL design process. The chapter began by discussing possible evaluation techniques, the reasons for chosing observational studies and protocol analysis of designers "think alouds". An initial experiment was described which showed that use of the ABC design method resulted in more pedagogic design discussion than in a CAL design developed without the use of any design method. In order to show that it was the ABC design method and not just application of *any* design method that had made the difference, a second experiment was conducted. This second experiment again confirmed that the ABC design method had enhanced the CAL design process by increasing the number of pedagogic design items that were discussed during the design process. Experiences of two CAL designers using the ABC design method were also discussed. Both designers overall found that the ABC design method helped them in their CAL design process.

6 Conclusions

6.1 Summary

The original claims of this dissertation were stated as:

1. A new design method — The ABC method — can be created based on a suitable model of the teaching and learning process for Higher Education — Laurillard's Conversational Framework.

2. The ABC method enhances the CAL design process, by focussing designers on pedagogic design issues.

Chapter 2 discussed the underlying model found in Instructional Systems Design, leading to a discussion of other educational models currently found in Higher Education. This chapter concluded that Laurillard's conversational framework was a suitable model to use as the basis for a new design method. Chapter 3 then discussed reviews performed on CAL packages using the conversational framework. This chapter also concluded that the framework was suitable. These discussions therefore support thesis claim (1).

Chapter 4 described the development of the design method through the use of scenarios and showed how it was refined through the development process to the completed method. Chapter 5 defined a method by which we can tell if a design has been enhanced. The chapter then described two sets of experiments performed to show the effect the design method has had on the CAL design process. Both of these experiments produced positive results showing that the design process had indeed been enhanced. Therefore thesis claim (2) is also satisfied.

Evidence gathered from the experimental subjects via a questionnaire also supports the positive influence the new design method has:

> *"I found the method a straightforward comprehensive way to design a teaching system. No prior knowledge of CAL design was assumed. The most beneficial aspect for me was that the designer is forced to concentrate on all aspects of the teaching and learning process, including student/teacher interactions and student reflection. It also allows for the fact that students will not always grasp concepts first time."*

"The design method provided a structure and greater understanding of the educational stages."

The design method... "makes you pay attention to all the important aspects of the activity and guides you in designing it."

Evidence gathered above, although encouraging for use of the ABC method, is anecdotal and must be used cautiously. One must be cautious of the Hawthorne effect (Preece et al 1994) in data such as above, since subjects may be telling the researcher what they think the researcher wants to hear.

6.2 Future Work

6.2.1 Further Evaluation

As stated in Chapter 2, design can be studied by examining the quality of the process or of the performance of the resulting artifacts. Due to time constraints on experimental subjects and the introduction of confounding variables as discussed in section 2.1, the evaluations performed for this dissertation considered the design process. It would be desirable to now consider design as artifacts and evaluate the end-product of the CAL design process. Some thought has been given to how such evaluations should be performed: expert evaluators would be required who could evaluate the CAL products against a set of evaluation criteria. The evaluation criteria would need to be carefully crafted to include all aspects of a CAL product that make it good, including user interface, usability issues, interactivity, educational content and integration with the rest of curriculum. An inherent difficulty is that the quality of the resulting artifacts depends on many factors besides the design as discussed in section 2.1.

6.2.2 Further Development of the Method

The evaluation questionnaire that subjects completed after Experiment 1 produced a number of useful suggestions for future development of the method.

Referring to the Design Templates that were used in the new method:

"The layout of the templates was slightly restrictive – possibly the templates could be made available on a disk to use in a word processor."

"The only difficulty I had was keeping track of the different templates. This is a volume problem — I don't know if there is anything that can be done."

Both of these comments suggest a computerised version of the ABC method and its associated documents. A computer version of the method would also allow the CAL case studies to be shown in their correct situation instead of black and white still screenshots. This could perhaps help to better inform people of CAL implementations of the activities in the ABC method.

Referring to the Activity Implementation Chart:

"I think there should be more detailed categories in the implementations e.g. video compared with interactive video."

"I think the Human-Human, Human-Computer and Other teaching modes are too general, they need to be more detailed to cover more types of interaction."

These comments support a refinement in the teaching modes used. Again, use of a software implementation of the method would allow the teaching modes to be more clearly illustrated: e.g. video clips could show lectures; extracts from CAL package could show actual activity implementation. It would also then be easy to provide a library of different implementations organised by discipline for example.

Referring to completion of Activity Implementation Charts:

"It might be useful exercise for an instructor to first brain-storm all their ideas in some kind of matrix for each category and then pick the best from that."

Again, this offers further support for software implementation. This would also allow a spreadsheet-type implementation where designers could simply select the most appropriate implementations from an onscreen selection.

6.2.3 Relationship to other Laurillard-based Work

Research under the LaTID project (Conole & Oliver 1997) discussed in Section 2.4.3.1. has also used Laurillard's conversational framework. They have used it to assign time values for developing resources for each activity of the framework under different media types. The LaTID project has also built up a matrix for showing which activities are commonly supported by various media types, enabling designers to make informed choices for their CAL product. It would be interesting to combine the LaTID work and the method described here. It would again seem to point to a software implementation of the method. The MCCA, also discussed in Section 2.4.3.1, begins a new design by identifying the learning styles of the individual learners. Mathers indicated this to be a weakness of the ABC Design Method in his evaluation. Although the idea of adapting teaching to students' individual learning styles is appealing, others have stated that it is not a simple problem:

> *"...The tendency to adopt a certain approach, or to prefer a certain style of learning, may be a useful way of describing differences between students. But a more complete explanation would also involve a recognition of the way an individual student's strategy may vary from task to task." Entwhistle 1981*

Further research in this area is required before inclusion of learning styles can be considered in the ABC design method.

6.3 Research Questions from this research

So far, this chapter has discussed the major outcomes and conclusions of the research conducted. In this section research questions which have arisen in discussions of the work presented in this dissertation are stated and discussed.

6.3.1 Why do we need a design method?

Some have asked why a design method is needed for CAL when so much of other Higher Education instructional material is created without the use of models or methods e.g. lectures or seminars. This is perhaps true but it must be remembered that most other teaching and learning materials are 'live' events that students and teachers take part in and can be modified in situ. For example, if a teacher is giving a tutorial and it is clear that a student does not understand a particular concept, the teacher is able to ask the student what part he/she does not understand, give an alternative description or additional example to aid the student's understanding. Imagine the same scenario but this time the tutorial takes place via CAL; the teacher is replaced by the computer and the student works through the tutorial at his or her own pace. The student then reaches a section where they do not grasp a concept. There is now no live teacher to explain further or provide another example. A well-designed piece of CAL would have highlighted that this could have been a potential problem and the CAL could have included further explanation and examples for a student to refer to.

Some may then ask why we need a design method based on an educational model, when there are many other software engineering models around e.g. the STAR lifecycle model (Hix & Hartson 1993). The purpose of CAL material is for a user to learn something from the educational experience. Software engineering models provide assistance in management and decomposition of an overall project. The models also guide a developer through the important phases in the design process (e.g. analysis, evaluation etc.) Software Engineering models do not, however, include any assistance for the design of educational activities which are at the core of a CAL package. Use of a specialist education design method, like the ABC method, provides the designer with general design process assistance but also vital assistance with designing educational content. Taking the same educational situation as described above, the ABC Method would have indicated the need for students to redescribe a concept and for the CAL package to provide the student with more description or examples. The STAR lifecycle model would not have considered this.

6.3.2 Should individual or groups of designers be used for experiments?

The experiments described in Chapter 4 set individual designers an instructional design task to complete. In order to observe and measure the design process that the designers are performing, they are asked to "think aloud" their design decisions. Use of "think-alouds" is a simple method to use in formative evaluations. However, some say that describing what you are doing often changes the way you do it (Dix et al, 1998) and that "thinking aloud" is not a natural process. To make the process seem more natural, groups or pairs of designers are used instead of individuals and their conversations recorded. Pairs or groups of designers interacting gets a more natural discussion dialogue going.

Despite the benefits of working with pairs of designers, there are also disadvantages to the approach: firstly, discussions can be biased towards a dominant participant in the group. Also the group approach takes significantly more subjects to run the experiment which in this particular study was infeasible.

However, the ABC design method was designed with the individual educationalist in mind. Higher education CAL has a long tradition of being produced by the enthusiastic individual subject matter expert. The ideal vision of a multidisciplinary design team made up of subject matter experts, graphic designers, computer programmers and instructional designers is still not widely available. The enthusiastic academic does not have the well-rounded knowledge available in such a team. The ABC method aims to fill in some of the gaps by providing an educational framework for their instructional material to be designed within. The final design that an academic comes up with may go on to be implemented by a team as acknowledged in the design templates of the ABC method.

6.3.3 Can Activity Implementations be reused?

The ABC Method promotes reuse of teaching and learning resources in a limited way by providing case studies of CAL activity implementations that may be appropriate in a new CAL design. The activity implementations allow reuse since they are relatively small and self-contained.

Recent initiatives such as the Instructional Management Systems Project (IMS Project 1998) have suggested that looking at smaller component sized pieces of CAL is the way for CAL to finally succeed in Higher Education. The IMS initiative believes that "By supporting a development process that encourages the reuse of existing materials, development costs will decrease and the incentives for investing in content production with a longer life span will increase." (IMS Project 1998) The IMS initiative hopes to address the issues of duplication of effort across institutions and increase the use of CAL, as discussed in section 1.2.

The overall goal of IMS is to facilitate the increased sharing of learning resources. IMS aims to achieve this goal by developing a number of standards for courseware, IMS looks at:

- Standards for describing learning resources.
- Communication protocols between learning resources.
- Accreditation for subsequent use of learning resources.
- Systems to manage the overarching delivery and handling of learning resources.

If the ABC Method adopted a standard description language, as proposed by IMS, for describing resources the possibility for subsequent reuse of the activity implementation would be greatly increased. It is possible to consider that the ABC Method's activities could be treated as IMS components, since the size of instruction that an activity implementation addresses is relatively small and self-contained. The ABC Method offers a pedagogically-based design framework for IMS in which the IMS component architecture can be fitted.

The marriage of IMS, the ABC Method, and the methods and techniques of software engineering, could provide an appropriate development structure for large-scale instructional development projects.

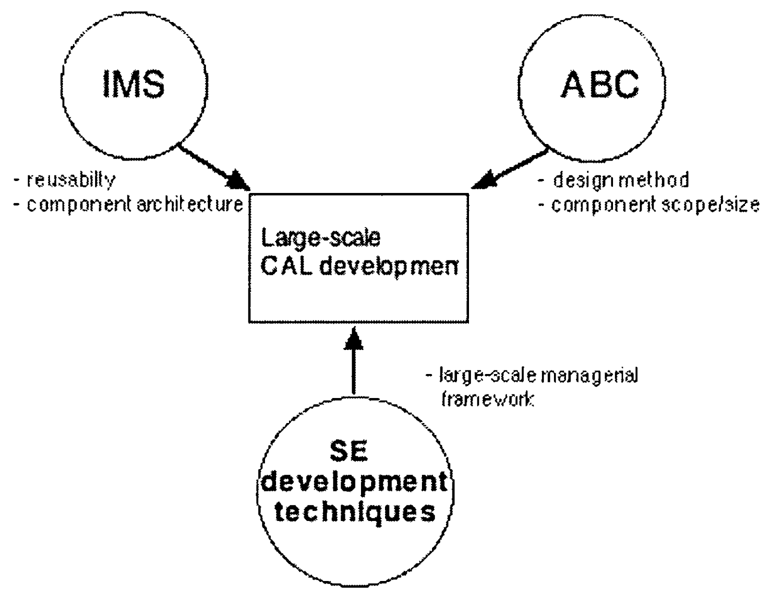


Figure 78 Large-scale CAL development

6.4 Conclusion

This dissertation has shown that a new design method based on a suitable educational model can be built and that use of this new method enhances the CAL design process. The major contributions of this dissertation are:

1. Creation of design method based on a suitable model of teaching and learning for Higher Education.

2. Use of scenarios in creating a design method.

3. Experimental evaluation of a design method.

There is now a design method that Higher Education CAL designers can use to produce CAL designs for their CAL applications, that is focussed on pedagogic issues.

Appendix 1: The ABC Design Method

You have made the decision to introduce CAL somewhere into the curriculum and have chosen to use the Practical Design Method[7] *to help assist you in the design process. You now need to know more about the Practical Design Method in order to make more decisions about your instructional design.*

Overview

This method aims to guide you through the design phase of the CAL development process. It is a practical, no-nonsense guide to designing and developing CAL in your curriculum. It considers issues of time and cost, indicates what CAL can do well, provides examples of CAL implementations, and a mechanism for evaluating your completed product. This method takes a new approach to CAL design — it considers the complete teaching and learning experience and where the CAL fits into this wider picture.

Contents

This design method pack contains a number of vital documents:

1 **The Teaching and Learning model**

The Practical Design Method is based on a particular model of the Teaching and Learning process. It is based on the Conversational Framework developed by Diana Laurillard. This framework is described and shown how it is used in the Practical Design Method.

2 **Cost and Time issues**

3 **Aims and Objectives**

4 **Activity Implementation Chart**

[7] The ABC Design Method was originally published as the Practical Design Method.

The Activity Implementation Chart describes various example ways of implementing activities from the Conversational Framework dependent on the teaching method chosen.

5 CAL Case Studies

The Case Studies illustrate how activities in the Conversational Framework have been implemented in other CAL packages.

6 The Design Method

A step-by-step guide to implementing CAL into your curriculum

7 Design Templates

1 The Teaching and Learning model

The Practical Design Method is based on a particular model of the Teaching and Learning process. It is based on the Conversational Framework developed by Diana Laurillard. The framework identifies twelve activities that should be performed by the teacher and learner for each learning objective.

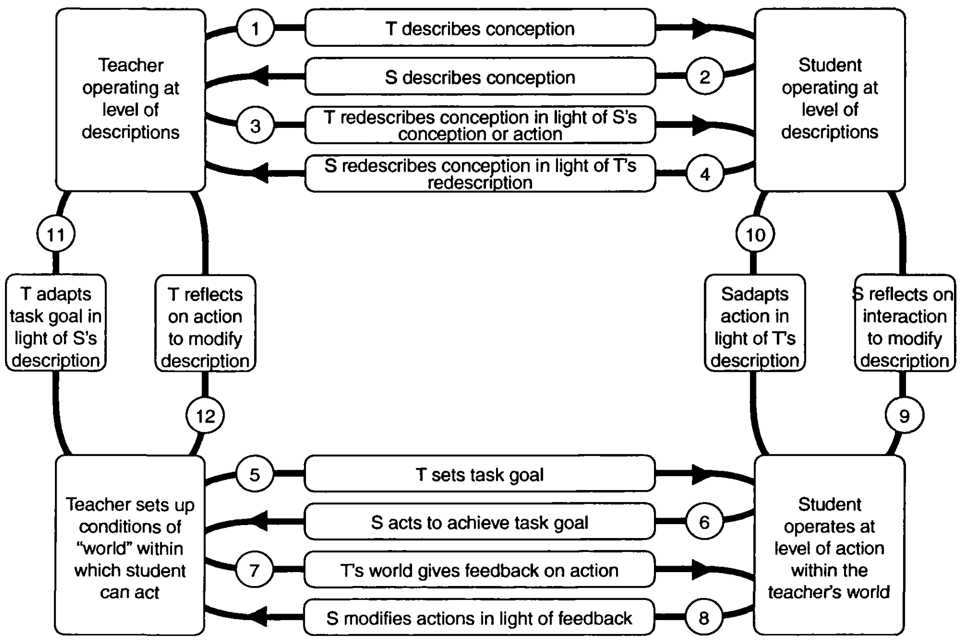


Figure 1 Laurillard's Conversational Framework

The activities are described as *mathemagenic* activities i.e. activities likely to promote learning. These activities fall into four categories: discursive, adaptive, interactive, and reflective. As the name suggests the "conversational framework" promotes a conversation or dialogue between learner and teacher, a more interactive view of teaching and learning.

The fundamental idea behind the conversational framework is that the teaching and learning process is a dialogue, a conversation in which both the teacher and learner participate. Laurillard states that in the university setting there are two levels of conversation for academic subjects. The first level is at the academic level, a shared vocabulary of words, the level of descriptions e.g. mathematical formulae, technical terms. The second level is at a more personal, reflective level, at the level of actions.

The framework consists of 12 actions and activities that Laurillard believes must take place in any learning experience — by traditional methods or by computer — to achieve a given topic goal in an academic subject.

It is easy to see from the framework diagram the conversation flow between teacher and student. There is a dialogue going on between both parties. The upper section of the diagram (activities 1–4) is concerned with the level of descriptions, the lower section (activities 5–8) with the more personal, reflective level of conversation. This is at the level of actions. The middle section (activities 9–12) link the two levels of conversation together. Here both parties reflect and adapt activities based on the other's actions and activities.

The twelve actions can be summarized as follows:

1. The learner listens to a teacher's exposition.

2. The learner describes the conception as they understand it, in the form of an essay or verbally.

3. The teacher re-describes the conception to the learner based upon activity 2 and provides feedback.

4. The learner re-describes their original attempts.

5. The teacher sets a task goal for the learner to complete.

6. The learner attempts to achieve the task set in activity 5.

7. The teacher provides feedback regarding the learner's attempts at the task.

8. The learner modifies their actions in the light of the feedback provided to the learner by the teacher.

9. The learner reflects upon the interaction at the personal level of the world in order to modify their conceptual descriptions.

10. The learner modifies their actions in the light of reasoning at the public level of descriptions.

11. The teacher modifies the task set to address some need revealed by the learner's descriptions or actions.

12. The teacher examines the learner's actions and modifies their description of the original conception.

2 Cost and Time issues

You have decided to implement and introduce CAL into your teaching. Before you go any further there are some time and cost issues you should consider; developing CAL takes a great investment both in time and also money.

Laurillard states that:

> *"The two key criteria for selecting specific areas of the curriculum for development are that topics must be a) taught widely and b) widely acknowledged to present difficulties for students."*

So consider carefully the anticipated benefits from the CAL implementation and introduction. It has been said that a realistic ratio to determine the number of hours of development time required is 300-500:1, i.e. one hour of material takes between 300 and 500 hours to produce. This figure is based on CAL with multimedia elements such as graphics and sound. CAL produced without these components would take significantly less time.

3 Aims and Objectives

The first thing you must do for any form of instruction is to identify its aims and objectives. Without these you can not proceed in an organised way.

Aims

Aims are normally considered to be broad or general statements of educational intent. They usually indicate the overall purpose or desired goal of the instruction.

E.g. in a basic chemistry course:

Aim: To develop an understanding of the properties of chemical bonds and of the principles of bonding.

Objectives

Objectives on the other hand are collections of more precise, more detailed statements relating to the fulfilment of specific aims and can usually be directly tested in an exam i.e., objectives are what must be done to achieve the overall aim.

E.g., again using the chemistry example:

Objective: At the end of the course, the student should be able to define the term 'orbital bonding' in terms of the probability of finding an electron in a given region of space.

or

Objective: At the end of the course, the student should be able to list 5 of the important properties of bonds.

Writing Objectives

Objectives need to be clear and unambiguous.

You should avoid using words such as "know."

7. E.g. "student should know the plays of Shakespeare."

Other words to avoid are “understand”, “appreciate.”

Instead, use words such as “state”, “explain”, “define”, “describe”, “predict”, “summarize”, “recognize”, “criticize.”

4 Activity Implementation Chart

This chart lists each activity in the Conversational Framework, and describes how each activity could be implemented in a variety of teaching modes: between a human teacher and student; between a student and computer teacher; and by some other means e.g. by the student reading a book. The implementation examples are intended to act as a guide and not to be an exhaustive and complete list of implementations.

	Teaching Mode	**Example**
	Human-Human	Teacher delivers lecture
	Human-Computer	Computer uses texts and graphics to deliver material
	Other	Student reads material in a book, watches video
	Human-Human	Student asks question in a tutorial, talks over conception, student sends email to teacher or to an online discussion group.
	Human-Computer	Student writes in electronic notebook their views of the conception, student

	r	performs an online quiz to test the understanding.
	Other	Student submits an essay expressing their view of the conception.

	Human-Human	Teacher gives another explanation, alters wording based on student's question in activity 2.
	Human-Compute r	Computer gives a 'canned' re-explanation based on common misconceptions.
	Other	Book suggests further reading for more explanation of the conception.

	Human-Human	Student asks question in a tutorial, talks over conception, student sends email to teacher or to an online discussion group.
	Human-Compute r	Student writes in electronic notebook their views of the conception.
	Other	Student submits an essay expressing their view of the conception.

	Human-Human	Teacher sets a lab practical.
	Human-Compute	Computer sets exercise to be performed.

	r	
	Other	Student performs an exercise from a book.

	Human-Human	Student attempts practical.
	Human-Compute r	Student performs exercise on computer.
	Other	Student attempts exercises in a notebook.

	Human-Human	Teacher grades practical and provides comments.
	Human-Compute r	Computer marks exercise and gives student grade.
	Other	Student looks at answers at back of book and compares with own answers.

	Human-Human	Student is allowed to try the practical set by teacher again.
	Human-Compute r	Computer allows the student to try the exercise again.

	Other	Student tries the exercise from the book again.

	Human-Human	Student reconsiders practical work they have done and changes their views of the theory delivered by lecturer.
	Human-Computer	Student reconsiders practical work they have done and changes their views of the theory delivered by computer.
	Other	Student reconsiders practical work they have done and changes their views of the theory read in book.
		(Can encourage this reflection by asking questions that elicit student's understanding.)

	Human-Human	Student reconsiders theory and changes the way they do practical set by teacher.
	Human-Computer	Student reconsiders theory and changes the way they do exercise set by computer.
	Other	Student reconsiders theory and changes the way they do exercise from book.

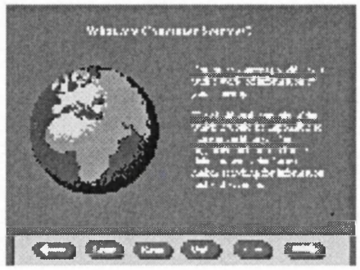
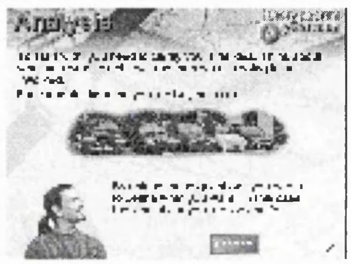
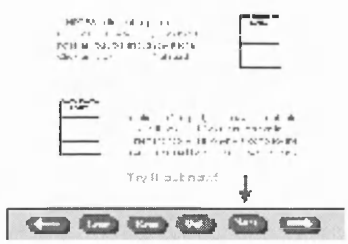
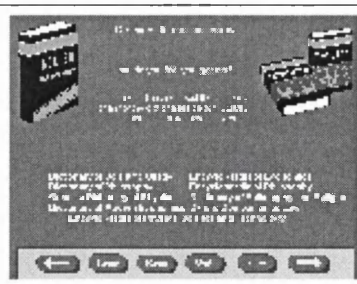
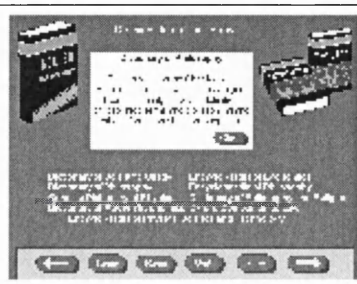
	Human-Human	Based on student's description of conception, teacher sets a different

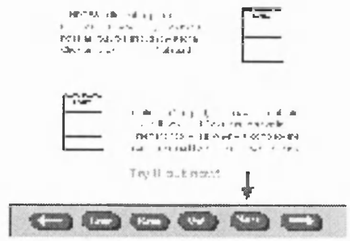
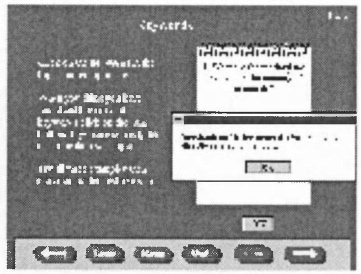
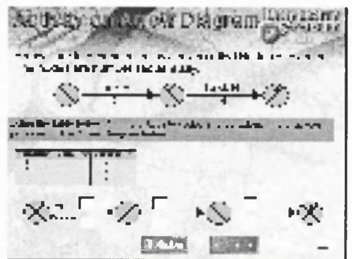
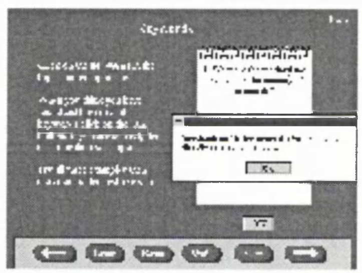
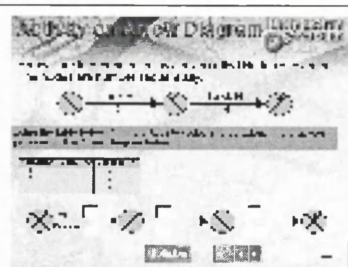
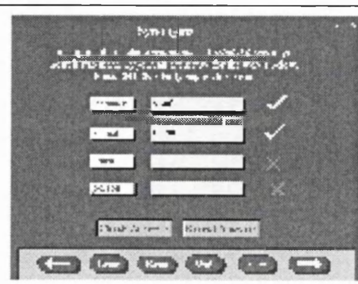
	Human	practical.
	Human-Computer	Computer sets a different exercise based on student's response to original exercise.
	Other	Book gives exercises to cover areas that students commonly have problems with.

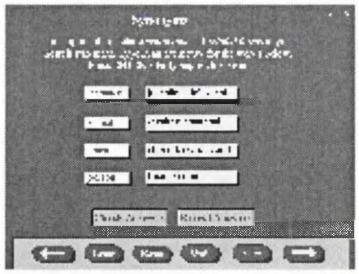
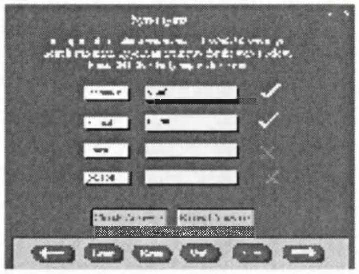
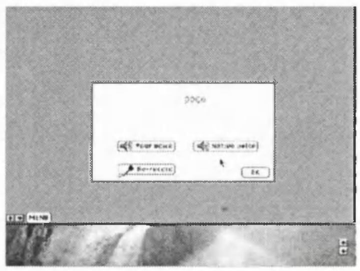
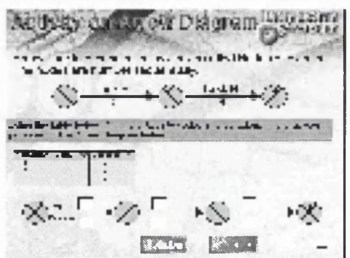
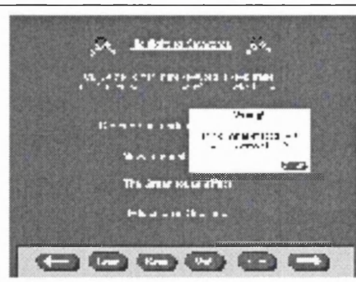
	Human-Human	Teacher rewrites their lectures that delivered main conception based on student actions.
	Human-Computer	CAL is rewritten based on student actions. Student actions can be recorded on the computer for later review.
	Other	Author rewrites sections of book due to reader's comments.

5 CAL Case Studies

This section illustrates how each of the activities in the Conversational Framework has been previously implemented in a CAL package with the use of screenshots from actual CAL packages.

Activity 1		A combination of text, graphics, photographs or video can be used to explain the chosen topic.
		
Activity 2		Use of an online electronic notebook allows the student to type in their understanding of the material so far.
Activity 3		Clicking on keywords provides user with more info on the terms used, giving a redescription of original material presented.
		

Activity 4		An electronic notebook could again be used to capture student thoughts.
Activity 5		The computer sets questions on the material for students to answer.
		
Activity 6		The student types in their responses or clicks on desired answer.
		
Activity 7		Simple ticks and crosses are used to provide student with feedback on their responses.

		Correct answers are provided should student require them.
Activity 8		The student is allowed to answer question again after some feedback has been given.
Activity 9		Student is encouraged to reflect between their response and the "textbook" response.
Activity 10		After some reflection between the theory and practice, student can attempt questions again with new-found insight.
Activity 11		Computer asks the question again but in a slightly different way when student got answer wrong.
Activity 12		Could be done — have canned description ready to present to user when something goes wrong.

1 State the aims and objectives of your instruction

2 Take each objective and go through the Conversational Framework, deciding how each activity will be supported by referring to the Activity Implementation Chart, case studies, and by filling in the Activity Implementation Template. Make as many copies of the template as you require for your objectives.

Example

Imagine you were teaching a course about the Ada computer programming language with the following identified aim and objective:

Aim: Understand the main concepts of Ada packages.

Objective: The student should be able to describe an Ada Package, its purpose and components.

If we start with Activity One, first we must decide how it is to be taught i.e. **the teaching mode** — will it be Human to Human i.e. a real teacher and student, Human to Computer i.e. a real student and computer teacher or by some other means altogether e.g. by the student reading a selected chapter in a book.

In this case we decide Human to Computer. Now we must decide how we will implement this activity. We look at the **Activity Implementation Chart** and see how Activity One has previously been achieved. We see that text and graphics can be used to implement this activity.

Choosing an Activity Implementation

It is at this stage that you must consider the **time and cost issues** mentioned earlier. A great deal of time and money can be spent creating graphics and shooting video for use in CAL. But is it really necessary? It might be that Activity One is already adequately supported by a series of lectures and that time and money might be better spent implementing another activity.

By completing the **Activity Implementation Design Template** (again make as many copies as is necessary) you can look at your overall design before an implementation has actually taken place and weigh up your design decisions.

You are able to try **alternatives** which perhaps take less time or money to implement, making your design more achievable. This also allows you to see how the CAL is integrated into the existing curriculum. Some activities may already be covered by traditional teaching methods and so by completing the Activity Implementation Design Template you can highlight which activities still need to be supported.

Use a friend or colleague to look over your initial design — check to see that it makes sense. Changes in your design at this stage are easy and cheap to make. Get your design correct at this stage and you will save yourself a great deal of time and effort.

3 Using the completed **Activity Implementation Template**, identify any resources that need to be acquired and use **the Resource Management Template** to catalogue and manage these resources.

4 Now simply implement your design!

5 Evaluation

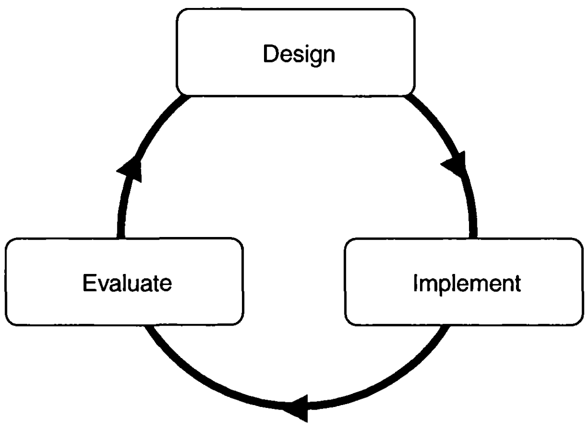
You have now implemented your CAL. In order to tell if it has achieved its objective you must evaluate it. A great deal of work has been done on evaluation of CAL (Draper et al). These evaluation methods evaluate the CAL packages in-situ and with real users. These type of evaluations are the most accurate test of your package and its usability and effectiveness to teach. However, a simple, quick method for you, the designer, to check if your package has achieved what you set out to do, is to compare it against the Conversational Framework once more.

	Activities Covered											
	1	2	3	4	5	6	7	8	9	10	11	12
Your Package Title	X	X			X	X					X	

Evaluation Table

Fill in the boxes for each activity. Be honest! The aim is to get as many black boxes as possible. If a blank appears, go back to your original design and see if it can be altered and then be achieved. If not, can it be done in a different teaching mode? E.g. the computer can not mark student essays but the human teacher could.

Continue this cycle of:



Design Lifecycle.

until you are satisfied with the package.

7 Design Templates

Included with this pack are two templates, which can be photocopied and used during the design process, as described above.

These design templates can of course be amended to deal with a number of people working on a project. Each Activity in the Activity Implementation Chart could also have a "Name" field, which would be assigned to a team member.

Activity Implementation Template

Title

Aim

Objective

Activity Number	Teaching Mode (H-H, H-C, Other)	Description

Resource Management Template

Title

Aim

Objective

Description	Resources Required	Acquired	Assembled

Appendix 2: Experiment 1 Pre Questionnaire Results

Subject	Designed Instructional Material Before?	Any Particular Method Used?
1	No	No
2	Yes	No
3	Yes	No
4	Yes	No
5	Yes	No
6	Yes	No
7	Yes	No
8	Yes	No
9	Yes	No
10	No	No
11	Yes	Yes
12	Yes	No
13	Yes	No
14	Yes	Yes
15	Yes	No
16	Yes	No
17	Yes	No
18	Yes	Yes
19	Yes	Yes
20	Yes	No

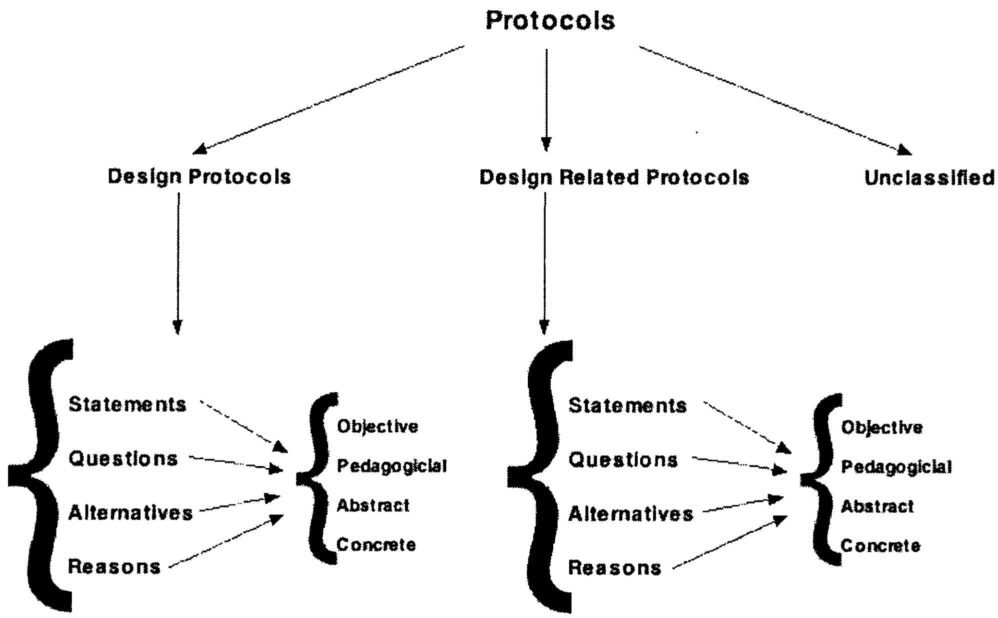
Summary

90% of subjects had designed instructional materials before.

80% of subjects had not used any particular method to design the instructional materials.

Methods used by subjects were iterative design, problem based learning, prototyping. It is interesting to note that only problem based learning provides any pedagogical guidance, which has been identified as being the important factor in the design of CAL.

Appendix 3 Complete Protocol Analysis Classifications



Appendix 4 Statistical Detail for Experiment 1

P=0.05
t-Test: Two Sample Assuming Equal Variances

	with method	without method
Mean	35.9	13.3
Variance	494.5444	106.0111
Observations	10	10
Pooled Variance	300.2778	
Hypothesized Mean Difference	0	
df	18	
t Stat	2.916298	
P (T<=t) one-tail	0.004608	
t Critical one-tail	1.734063	
P (T<=t) twin-tail	0.009215	
t Critical twin-tail	2.100924	

p=0.001
t-Test: Two-Sample Assuming Equal Variances

	with method	without method
Mean	35.9	13.3
Variance	494.5444	106.0111
Observations	10	10
Pooled Variance	300.2778	
Hypothesized Mean Difference	0	
df	18	
t Stat	2.916298	
P (T<=t) one-tail	0.004608	
t Critical one-tail	3.610476	
P (T<=t) twin-tail	0.009215	
t Critical twin-tail	3.921741	

Appendix 5: The Systems Approach Method

Teaching and Learning in Higher Education 1

Series 4

The Systems Approach to Course and Curriculum Design

The Scottish Central Institutions Committee for Educational Development

Title Page of Systems Approach Method

The Systems Approach to Course and Curriculum Design

Introduction

This booklet gives a general introduction to the concept of a systems approach to the development of courses and curricula. It begins by defining the systems approach in an education context, and giving an example of such a system which may be of use in the process of course design. The particular elements of this system are then briefly described. Finally, an indication of how the systems approach can be used in practice is given.

The Systems Approach

The 'systems approach' is at the heart of an 'educational technology' approach to course and curriculum design. It is an attempt to ensure that course development or other educational innovations are systematically and logically planned, implemented and evaluated. However the terms 'system' and 'systems approach' are jargon terms and can be off-putting. Let us, therefore, first take a look at these terms in order to define the way in which we are to use them here.

In an educational context (as well as most others), a *system* is any collection of interrelated parts that together constitute a larger whole.

These component parts, or *elements*, of the system are intimately linked with one another, either directly or indirectly, and any change in one or more elements may affect the overall performance of the system, either beneficially or adversely. A simple system is illustrated schematically in Figure 1.

In Figure 1, the system consists of four distinct elements A, B, C, D which are related to or dependent upon each other as indicated. Note that some interrelationships may be two-way, while others may be one-way only.

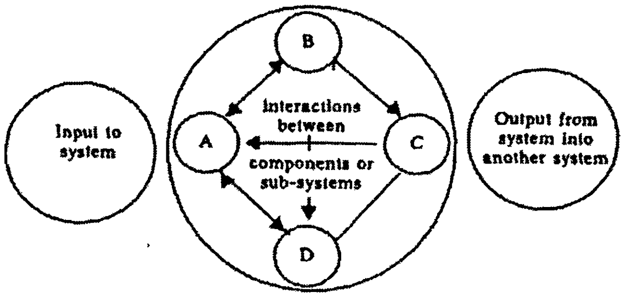


Figure 1: A typical system

These elements may themselves be capable of further breakdown into other smaller components, and may thus be regarded as ***sub-systems*** of the overall system.

The processes of education and learning can be considered to be very complex systems indeed. The input to a given educational or learning system consists of people, resources and information, and the output consists of people whose performance has (it is to be hoped) improved in some desired way. A schematic representation of systems of this type is shown in Figure 2.

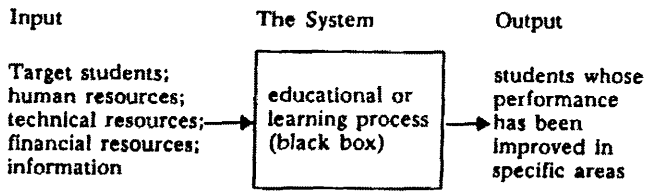


Figure 2 : The 'systems' model of the educational or learning process

In such a system, the educational or learning process may be so complex that it can only be considered as a "black box' whose mechanisms are not fully understood. However, research into the nature of the learning process has thrown *some* light on what happens inside the 'black box'.

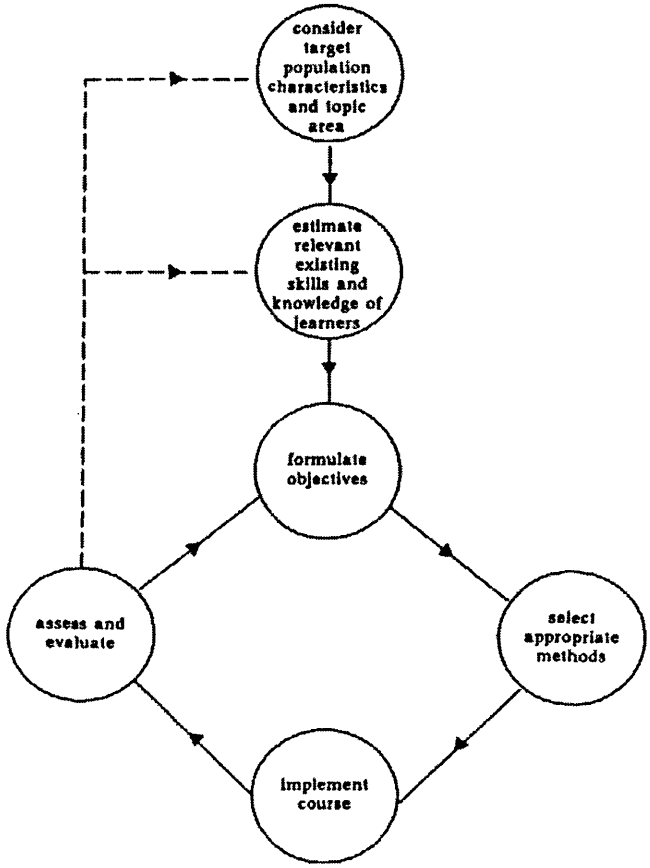


Figure 3: A simplified systems approach to course design

3

Systems Approach Method:Page 3

This has enabled educationalists to structure the input to systems of this type in such a way as to try to improve the output through increasing the efficiency of the learning process, thus leading to a systems approach to course design based on existing knowledge of how people learn. Such a systems approach attempts to mould the input to a course in such a way as to enable the optimum assimilation of knowledge and skills to take place during the learning process and hence maximise the quality of output.

A simple system for the design of teaching/learning situations is given in Figure 3. We have deliberately chosen an extremely basic example of a systems approach to course design. Other writers (for example, Romiszowski, in his book "*Designing Instructional Systems*") have described more sophisticated systems, but these would be unnecessarily complicated for our present purposes. The components of the system all have sub-elements, which are discussed in detail in the other CICED booklets.

Elements in the Systems Approach

(a) Consider target population characteristics and topic area

The range of background, interests, knowledge, attitudes and skills of students coming on to the course will have a strong influence on course design. Pre-knowledge and any common misconceptions will have to be catered for in the design of the course (eg these may affect sequence, structure and support mechanisms).

The broad thrust of the course content will have to be considered. Consideration will be given to the sort of people which the course is trying to develop. The subject area may have traditional aims and directions, but one may wish to consider the justification of these.

(b) Estimate relevant existing skills and knowledge of learners

There may be minimum standards of entry to the course, but this will not always be so. For example, the increasing numbers of non-standard and/or mature student entrants to higher education will not necessarily have 'paper' qualifications, but may possess skills and qualities which will have an influence on course design. This may have implications for teaching methods, bridging courses, support systems etc.

(c) Formulate Objectives

The formulation and role of objectives in the systems approach are dealt with in detail in CICED Booklet 1 (Series 1). The objectives of the course will attempt to encapsulate the new skills, knowledge and attitudes which the students will gain from the course. The objectives may be formulated by learners, employers, teaching staff, a validating or examining body, or by some combination of these and other sources.

(d) Select Appropriate Methods

Having specified objectives (that is, exactly what we are trying to achieve in the course), we should be in a better position to select appropriate teaching/learning methods through which the objectives have a reasonable chance of being achieved. There are far more teaching methods available to choose from than most people realise – one recent book describes no less than 303 different teach/learning methods! The process of attempting to match appropriate methods to given objectives is normally done on the basis of a combination of research and experience. The strengths and weaknesses of a range of different teaching and learning methods are covered by other CICED booklets.

(e) Implement Course

The next element in the system is the actual implementation of the course. This involves all the logistical arrangements associated with running a course, including structuring, pacing, teaching strategies, selecting appropriate media, and ensuring that all aspects of the course run as smoothly as possible.

(f) Learning Experience

The combined result of the preceding stages is that students are involved in a learning experience that is planned to develop their

The three main classes of instructional methods

Despite the large number and great variety of instructional techniques available, it is possible to divide them into three broad groups, namely, *mass instruction techniques*, *individualised learning techniques* and *group learning techniques*. As can be seen from Table 1, these not only differ in terms of teaching/learning mode, but also place the teacher in radically different roles.

Table 1: the three basic classes of instructional methods

Class of techniques	Examples	Role of teacher
Mass instruction	Conventional lectures and expository lessons; television and radio broadcasts; cable television; films and videos.	Traditional expository role; controller of instruction process.
Individualised learning	Programmed learning; mediated self-instruction; computer-based learning.	Producer/manager of learning resources; tutor and guide.
Group learning	Tutorials; seminars; group projects; games and simulations.	Organiser and facilitator.

2

Table 2: characteristics of some of the main mass instruction techniques

Technique	Strengths	Weaknesses
Lectures and similar expository techniques.	• Can be very cost effective in terms of student/staff ratio. • Strong in achieving lower cognitive and *some* affective objectives. • Generally popular with both students and staff.	• Strongly dependent on skill of individual lecturer or teacher. • Weak in achieving most higher cognitive and affective objectives; not suitable for achieving psychomotor objectives or developing communication skills, interpersonal skills, etc. • Student involvement generally low or non-existent. • Pace controlled by teacher; does not allow for different learning rates. • Most lectures are too long for the concentration span of students.
Film and video presentations.	• Can be a highly-effective substitute for a lecture or part thereof *if the content and level are suitable.* • Can be used to provide realistic illustrative, supportive, background and case-study material. • Tend to be highly stimulating.	• Can be a waste of time unless content and level are appropriate. • Teacher effectively relinquishes control of teaching process to maker of film or video during presentation. • Cannot be used unless suitable hardware is available. • Can be expensive.
Educational broadcasts.	• Same basic strengths as film and video presentations, with further advantage that broadcasts are free.	• Same basic disadvantages as film and video presentations (with exception of cost). • Also, timing of broadcasts is generally fixed, making them difficult (or impossible) to fit into a timetable unless they can be recorded - something that can only be done *legally* with certain broadcasts.
Mass practical and studio work.	• Can be effective in developing psychomotor and associated skills. • Can help demonstrate relevance of theoretical content of a course. • Students generally enjoy their participative nature.	• Can be a waste of time unless the activities chosen are relevant to the main content of the course. • Generally expensive in terms of time, manpower, equipment and materials. • Often weak in terms of higher cognitive objectives unless very carefully planned.

5

Systems Approach Method:Page 7

Table 3. Characteristics of some of the main individualised learning techniques

Technique	Strengths	Weaknesses
Directed study of material in textbooks.	• Can be a highly effective way of teaching basic facts, principles, applications, etc., provided that suitable texts are available and the work is is carefully structured. • Allows learner to work at his/her own natural pace. • Needs no specialised facilities other than a suitable library.	• Requires careful planning and structuring on part of teacher. • Dependant on suitable texts being available in sufficient numbers to cater for the size of class carrying out the work. • Not suitable for achieving many higher cognitive and non-cognitive objectives.
Study of specially-prepared notes or programmed texts.	• Same basic advantages as directed study of books, and can be even more effective if the material is well prepared. • Can allow learners to interact with the material.	• Preparing suitable material can be very time consuming. • Again, not suitable for achieving many higher cognitive and non-cognitive objectives.
Self-instruction via audiovisual media (audiotapes, video-tapes, tape/slide programmes etc).	• Enables a wide range of educational objectives to be achieved (especially lower cognitive). • Allows learner to work at his/her own pace. • In addition, use of mediated presentation enables sound, movement, realism, etc. to be introduced, thus increasing student stimulation. • Can save teachers from having to carry out repetitive, time-consuming work (e.g. teaching certain basic laboratory skills).	• Ideal ready-made courseware seldom available, and preparation of custom-designed material can be both time-consuming and expensive, as well as requiring specialist skills. • Again, not suitable for achieving many higher cognitive and non-cognitive objectives. • Cannot be used unless suitable hardware is available; this can be expensive to provide.
Computer-based learning.	• Enables a wide range of educational objectives to be achieved (especially lower cognitive). • Allows learner to work at his/her own pace. • Can allow considerable interaction between learner and instructional programme, and can adapt to needs of learner; can be highly stimulating. • Can provide (through computer simulations) a wide range of otherwise inaccessible learning experiences. • Allows on-going assessment and monitoring to take place automatically.	• Same basic weaknesses as mediated self-instruction. • In addition, requires computer literacy and (in many cases) a high degree of programming skill on the part of the teacher.
...ividual practical ...dio or project ...rk	• Same basic strengths as mass practical and studio work. • Allows students to work at their own pace.	• Same basic weaknesses as mass practical and studio work.

Systems Approach Method:Page 8

Table 4: characteristics of some of the main group learning techniques

Technique	Strengths	Weaknesses
Buzz sessions and similar short small-group exercises.	• Constitute an excellent method of introducing variety into a lecture, thus helping to maintain student attention. • Can be used to achieve a wide range of objectives, both cognitive and non-cognitive. • They get students *actively* involved in a lesson. • They allow feedback to take place.	• They are most useful in a *supportive* role as part of a larger lesson as they are not, by themselves, intended for use as a front-line method of teaching basic facts and principles.
Class discussions, seminars, tutorials, etc.	• Same basic advantages as buzz sessions, etc. • In addition, their greater length allows an even wider range of objectives to be achieved, often of a very high level. • Enable relevant topics to be examined in great depth.	• There is a danger that not all the members of a class will take an active part in the exercise *unless steps are taken to make sure that they do.* • They can cause timetabling problems if a class has to be split up.
Participative exercises of the game/simulation/case study type.	• They can be used to achieve a wide range of objectives, both cognitive and non-cognitive, often of a very high level. • High student involvement. • Highly stimulating and motivating if properly designed. • Ideal for cross-disciplinary work.	• Most useful in a supportive or illustrative role rather than as a front-line method of teaching basic facts and principles. • Can be difficult to fit into curriculum, especially in case of long exercises. • Must be *relevant to course* to be of real educational value.
Mediated feedback sessions such as microteaching, recorded interviews, or recorded group exercises.	• Use of mediated feedback (eg audio or video recording) enables valuable group discussions of student performance to take place. • Can be used to develop a wide range of skills. • High student involvement.	• Some students find method off-putting at first. • Requires suitable hardware and other facilities, often expensive • Can cause timetabling problems if a class has to be split up.
Group projects.	• Suitable for developing a wide range of objectives, both cognitive and non-cognitive, often at a very high level. • Ideal for developing interpersonal and group skills. • Ideal for cross-disciplinary work.	• There is a danger that not all the members of the group will pull their weight unless steps are taken to make sure that they do. • Assessment of contributions made by individual students can be difficult.

9

Appendix 6: Experiment 2 Pre-Questionnaire Results

Subject	Designed Instructional Material Before?	Any Particular Method Used?
1	Yes	No
2	No	No
3	Yes	No
4	Yes	No
5	Yes	No
6	Yes	No
7	No	No
8	Yes	Yes
9	No	No
10	No	No
11	No	No
12	No	No
13	No	No
14	Yes	No
15	Yes	No
16	Yes	No
17	Yes	No
18	No	No

Summary

56% of subjects had designed instructional materials before.

95% of subjects had not used any particular method to design the instructional materials.

The method used by 5% of subjects was prototyping.

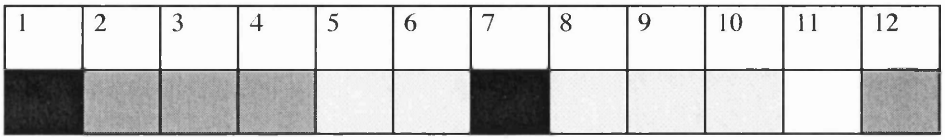
Appendix 7: Statistical Detail for Experiment 2

P=0.05
t-Test: Two Sample Assuming Equal Variances

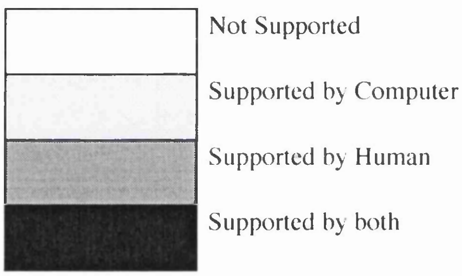
	method A	method B
Mean	17	13.3
Variance	184.8889	632.7667
Observations	10	10
Pooled Variance	408.8278	
Hypothesized Mean Difference	0	
df	18	
t Stat	-6.403145	
P (T<=t) one-tail	2.49E-06	
t Critical one-tail	1.734063	
P (T<=t) twin-tail	4.99E-06	

Appendix 8: CAS Conversational Framework Evaluation

Activity Number



Guide



Appendix 9: Evaluation Questionnaire

The Practical Design Method: Evaluation Questionnaire

1. Why did you use the Practical Design Method?

2. Had you used any other design methods before?

   If so please state them:

3. Now that you have used the Practical Design Method, how will it affect your work in the future?

4. What do you think the purpose of a design method is?

5. Did the Practical Design Method perform this purpose?

6. Now let us look at the Practical Design Method document in detail and decide what parts you found useful or not, as the case may be!

If you did not use a section please tick "not used." In the "Reasons and comments" column put an explanation for your answer or any general comments you have for that section.

Section	**Not at all useful**	**not very useful**	**useful**	**very useful**	**extremely useful**	**not used**	**Reasons and Comments**
1 Teaching and Learning Model							
2 Cost and time							
3 Aims and objectives							
4 Activity Implementation Chart							
5 CAL Case study							
6 Design Methods							
7 Design Templates							

7. Did you find the Practical Design Method easy to use?

If not, why? How could it be improved?

8. Did you find it easy to manage the completed templates and other documents required for the Practical Design Method?

Could this have been improved?

9. Did the black and white screen shots adequately capture the activity in the CAL Case studies?

Any suggestions for improvements?

10. Did you find the provision of blank design templates useful?

Please explain your use of the templates:

Could these have been improved?

11. Do you think using the Practical Design Method has enhanced your CAL design?

Explain how:

12. Have you any general comments on the Practical Design Method and its use?

Name: **Date:**

Appendix 10: Review Packages

CAL Package Descriptions

1 Planner

An interactive multimedia tutorial on project analysis and project planning

2 Computer Sources

A general module on database search techniques dealing with the general principles of using online and CD-ROM bibliographic sources. The areas covered include keywords, boolean, truncation, controlled vocabulary and citation searching.

3 Library Skills

This package deals with the whole search strategy, including how to use reference works, highlight keywords, find synonyms and related terms, and generate terms.

4 Library Study Skills

This package gives an overview of the basic concepts of study skills, time management, note taking in lectures, reading, writing, presentation skills, and revision. It includes references for further information on the topic and suggests whom to contact for advice with problems.

5 How to Choose Books and Journals

This package deals with the evaluation of books and journals. It covers the areas of scanning, skimming, analysing and assessing.

6 Dental CAL

Package includes an introduction to dental instruments and their use, explains CPITN (a dental chart system), information about plaque and periodontal disease and how to record plaque and gingivitis chart.

7 Dental Pocket Charting Assistant

This package is a simulation environment to analyse and chart dental data as would be done during real clinical session with patient.

8 Sharpening Dental Instruments

Package uses animation to show various techniques of sharpening dental instruments.

9 Fast Fracture

Deals with the mechanical engineering phenomenon of Fast Fracture of materials (failure of stressed materials), also presents a comparative analysis of the fracture process in ductile and brittle materials.

10 Aquatanian Chant Music

A collection of reference resources and interactive exercises on Aquatanian Chant Music.

11 16th Century Musicianship

Package covers dictation-based exercises including single line and two part dictation, stylistic "spot the mistake" exercises and choosing correct pitch and location for imitation.

12 Parasitism

Software for teaching neurophysiology. Simulation package dealing with demography prevalence of disease.

13 De Tudo Um Pouco

A scenario based Portuguese language package to practice spoken language skills with task based and "drill & practice" exercises

Appendix 11: Activity Implementation Charts from Firefighter Training Evaluation.

Activity	Teaching Mode	Example
1	H-H	Officer in Charge / Junior Officer gives lecture
	H-C	
	Other	Firefighter reads lecture notes / watches training video
2	H-H	Firefighter asks question at the end of lecture
	H-C	
	Other	
3	H-H	Officer in Charge / Junior Officer explains answer to question
	H-C	
	Other	
4	H-H	Firefighter asks question about answer
	H-C	
	Other	
5	H-H	
	H-C	
	Other	
6	H-H	
	H-C	
	Other	
7	H-H	
	H-C	
	Other	
8	H-H	
	H-C	
	Other	
9	H-H	
	H-C	
	Other	Callout – reflection on technical training
10	H-H	
	H-C	
	Other	Firefighter reconsiders theory and changes views of Practical
11	H-H	
	H-C	
	Other	
12	H-H	
	H-C	
	Other	

Technical Training Cycle Activity Implementation Chart

Activity	Teaching Mode	Implementation
1	H-H	Demonstration given
	H-C	
	Other	Firefighters watch VIDEO
2	H-H	Firefighters ask questions if unclear
	H-C	
	Other	
3	H-H	Questions explained by demonstrator
	H-C	
	Other	
4	H-H	Firefighters ask questions if unclear
	H-C	
	Other	
5	H-H	Drill is set for firefighter
	H-C	
	Other	Firefighters are called out
6	H-H	Fire Fighters do drill
	H-C	
	Other	Fire fighters put out fire/save cat from tree/ etc
7	H-H	Feedback given to firefighters after drill
	H-C	
	Other	Debriefing after incident
8	H-H	Firefighters repeat drill (if enough time)
	H-C	
	Other	
9	H-H	Firefighter reflects on drill/callout and changes view of drills
	H-C	
	Other	
10	H-H	Firefighter reconsiders drill and changes the way they do theory
	H-C	
	Other	Firefighter learns from debriefing after callout
11	H-H	
	H-C	
	Other	
12	H-H	
	H-C	
	Other	

Practical Training Cycle Activity Implementation Chart

Appendix 12: Ross Evaluation Templates

Appendix M: Sample Walkthrough Pedagogical Evalution

The "Introduction To Oxfam" module was subject to a walkthrough evaluation, using the Evaluation Template of the Practical Design Method

The completed templates are below.

Testing Result Codes
Y - activity is covered
X – activity is not covered
* - activity is covered, but there is scope for future refinement

Evaluation Templates: Introduction To Oxfam

Aim: Increase baseline knowledge of Oxfam. **Activities Covered**

	1	2	3	4	5	6	7	8	9	10	11	12
State Oxfam's overall aim and understand the concept of basic rights;	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	X	X

Aim: Increase baseline knowledge of Oxfam. **Activities Covered**

	1	2	3	4	5	6	7	8	9	10	11	12
Be aware of the structure of the organisation	Y	Y	Y	Y	X	X	X	X	Y	Y	X	X

Aim: Increase baseline knowledge of Oxfam. **Activities Covered**

	1	2	3	4	5	6	7	8	9	10	11	12
Identify Oxfam's main activities and their contribution to the overall aims.	Y	Y	Y	Y	Y	Y	Y	Y	X	X	X	X

Aim: Increase baseline knowledge of Oxfam. **Activities Covered**

	1	2	3	4	5	6	7	8	9	10	11	12
Be aware of Oxfam's costs and accountability.	*	Y	Y	Y	Y	Y	Y	Y	Y	Y	X	X

Appendix 13: Independent Evaluator's Classification

Conversational Framework CAL Review

Package Name: Planner

Activity	Supported
1	✓
2	
3	
4	
5	✓
6	✓
7	✓
8	✓
9	
10	✓
11	
12	

29/6/00

Conversational Framework CAL Review

Package Name: Library Skills

Activity	Supported
1	✓
2	✓
3	
4	
5	✓
6	✓
7	✓
8	✓
9	
10	✓
11	✓
12	

29/6/00

Conversational Framework CAL Review

Package Name: De Tudo Um Pouco.

Activity	Supported
1	✓
2	
3	
4	
5	✓
6	✓
7	✓
8	✓
9	
10	✓
11	
12	

29/6/00

Appendix 14: Publications from this dissertation

M Montgomery Masters, A Laurillardian CAL Design Method — Developed and Implemented, Proceedings of Ed-Media '98, Association for the Advancement of Computing in Education, p1746-1747, June 1998.

M Montgomery Masters, The Practical Design Method, Technical Report, Department of Computing Science, University of Glasgow, TR1998-1, January 1998.

M Montgomery, Developing a Laurillardian design method for CAL, Proceedings of Ed-Media '97, Association for the Advancement of Computing in Education, June 1997.

M Montgomery, A Third use for scenarios — improving CAL Design Methods, Accepted for publication by DIS '97, April 1997.

M Montgomery, Learning design by intention not by accident, Proceedings of ALT-C '96, Integrating technology into the curriculum, Oxford, September 1996.

7 References

Alberti, L. B. (1988). *On the Art of Building in Ten Books.* Cambridge, MIT Press. (Original work published in 1450.)

Anglin, G. J. (1991). *Instructional Technology Past, Present and Future.* Englewood, Colorado.

Archer, L. B. (1965). *Systematic Method For Designers.* Council of Industrial Design, London.

Arnold, S., Barr, N., Donnelly, P., Duffy, C., Gray, P., Morton, D., Neil, D., & Sclater, N. (1994). *Constructing and Implementing Multimedia Teaching Packages.* Robert Clark Centre for Technological Education, University of Glasgow. University of Glasgow Publication.

Barker, P. (1989). Designing Interactive Learning. In T. de Jong & L. Sarti (Eds.), *Design and Production of Multimedia and Simulation-based Learning Material.* Kluwer Academic Publishers.

Bednar, A. K., Cunningham, D., Duffy, T. M., & Perry, J. D. (1991). Theory into Practice. In *Instructional Technology: Past, present and future.* Englewood.

Blunkett, D. (1998). *The Learning Age: Government Consultation on Lifelong Learning (Green Paper).* Department of Education and Employment.

Boehm, B. (1988). A Spiral Model for Software Development and Enhancement. *Computer, 21, 5, 61-72.*

Branson, R. K., & Grow, G. (1987). Instructional systems development. In R. Gagne (Ed.), *Instructional Technology: Foundations.* Lawrence Erlbaum.

Briggs, L. J. (Ed.) (1977). *Instructional Design.* Englewoods Cliffs.

Brooks, F. P, (1975. *The Mythical Man-Month*, Addison-Wesley, Reading, Mass., New York.

Brooks, F., P., (1987). No Silver Bullet – Essence and Accidents of Software Engineering. *IEEE Computer, 10-19.*

Brown, J. S., Collins, A. & Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher*, 18(1), 32-42.

Bruner, J. (1962). *On Knowing, Essays for the Left Hand.* Belknap Press of Harvard University Press.

Bruner, J. (1966). *Toward a Theory of Instruction.* Cambridge, Harvard University Press.

Budgen, D. (1993). *Software design*, Addison Wesley.

CTI Primer (1998). *Use of C&IT.* Issue 1, CTISS Publications. (Online). Available via WWW http://www.cti.ac.uk/publ/primers.

Carey, T., Harriagan, K. & Palmer, A. (1998). *Mediated Conversations for Cognitive Apprenticeship: A Visual Tool for Instructional Designers.* (Online). Available via WWW http://watserv1.uwaterloo.ca/~tcarey/converse.html.

Carroll, J. M. & Rosson, M. B. (1992). Getting around the Task-Artifact Cycle: How to make claims and Design by Scenario. *ACM Transactions on Information Systems*, 10(2), 181-212.

Carroll, J. M., (Ed). (1995). *Scenario-Based Design – Envisioning Work and Technology in System Development.* John Wiley & Sons.

CICED. (1990). *The Systems Approach to Course and Curriculum Design.* The Scottish Central Institutions Committee for Educational Development.

Collins, A., Brown, J. S.,, & Newman, S. E. (1989). Cognitive Apprenticeship:teaching the crafts of reading, writing and mathematics. In Resnick, L. B. (Ed.), *Knowing Learning and Instruction: Essays in honor of Robert Glaser.* Lawrence Erlbaum.

Conole, G. & Oliver, M. (1997). *A Pedagogical Framework for Embedding C&IT into the Curriculum.* (Online). Available via WWW http://www.unl.ac.uk/laitd/elt/report2.htm.

Coopers & Lybrand (1996). *Evaluation of the Teaching and Learning Technology Programme*, Final Report. HEFCE Publication.

Creanor, L., Durndell, H., Henderson, F. P., Primrose, C., Brown, M. I., Draper, S. W., & McAteer, E.. (1995). *A Hypertext Approach to Information Skills: Development and Evaluation.* Robert Clark Centre for Technological Education, University of Glasgow. University of Glasgow Publication.

Dalgarno, B. (1996). Constructivist Computer Assisted Learning: Theory and Techniques. *Proceedings of ASCILITE 96, Australian Society for Computers in Learning in Tertiary Education.*

Dearing, R. (1997). *Higher Education in the Learning Society.* National Committee of Inquiry into Higher Education, HMSO and NCIHE Publications.

Dick, W., & Carey, L. (1990). *The systematic design of instruction* (3rd ed.). Scott, Foresman & Company.

Dix, A., Finlay, J., Abowd, G., & Beale, R. (1998). *Human-Computer Interaction.* Second Edition. Prentice Hall.

Dixon, J. R., Duffey, M. R. (1990). *The neglect of engineering design.* California Management Review, 32, 9-23.

Doughty, G., Arnold, S., Barr, N., Brown, M., Creanor, L., Donnelly, P. J., Draper, S. W., Duffy, C., Durndell, H., Harrison, M., Henderson, F., Jessop, A., McAteer, E., Milner, M., Neil, D. M., Pflicke, T., Pollock, M., Primrose, C., Richard, S., Sclater, N., Shaw, R., Turner, I., van der Zwan, R., Watt, H. D., (1994). *Using Learning Technologies: Interim Conclusions from the TILT Report.* Robert Clark Centre for Technological Education, University of Glasgow. University of Glasgow Publication.

Draper, S. W., Brown, M. I., Edgerton, E., Henderson, F. P., McAteer, E., Smith, E. D., Watt, H. D. (1994). *Observing and Measuring the Performance of Educational Technology.* Robert Clark Centre for Technological Education, University of Glasgow. University of Glasgow Publication.

Draper, S. W. (1994). Education as Communication. In (Eds.) Lewis, R. & Mendelsohn, P, *Lessons from Learning.* IFIP Technical Committee 3, 155-166. IFIP Publication.

Draper, S. W. (1997). Niche-based Success in CAL. *Computers and Education*, 30, 5-8.

Dunn, T. G. (1994). If we can't Contextualize it, Should we teach it? *Educational Technology Research & Development*, 42 (3), 83-92.

Entwhistle, N. J. (1981). *Styles of Learning and Teaching: An Integrated Outline of Educational Psychology*. John Wiley.

Ericsson, K. A., & Simon, H. A. (1993). *Protocol Analysis: Verbal Reports as Data.*, MIT Press.

Gagne, R. (1962). Military training and principles of learning. *American Psychologist*, 17, 263-276.

Gagne, R. (1985). *The conditions of learning* (4th ed.). Holt, Rinehart, & Winston.

Gagne, R. M., Briggs, L. (1974). *Principles of instructional design.* Holt, Rinehart and Winston.

Gagne, R. M., Briggs, L., & Wager, W. (1992). *Principles of instructional design.* Harcourt Brace Jovanovich.

Geoghegan, W. H., (1994). What ever happened to Instructional Technology*? In Proceedings of 22nd Annual Conference of the International Business Schools Computing Association.* Maryland.

Goel, V., & Pirolli, P. (1992). The Structure of Design Problem Spaces. *Cognitive Science*, 16, 395-429.

Government White Paper, *Higher Education : A New Framework*, 1991.

Government Green Paper, *The Learning Age: a renaissance for a new Britain,* 1998.

Guindon, R. (1990). Knowledge Exploited by Experts during Software System Design. *Intl J. Man-Machine Studies*, 33, 279-304.

Harrison, C. (1994). The role of learning technology in planning change in curriculum delivery and design. *ALT-J*, vol 2, no. 1, 30-37.

Hartson, H. R. & Hix, D. (1989). Towards empirically derived methodologies and tools for HCI development. *International Journal of Man-Machine Studies, 31, 477-494.*

Herrington, J., Oliver, R. (1996). The effective use of interactive multimedia in education: Design and implementation issues. *In The learning superhighway: New world? New worries?* Promaco Conventions.

Hix, D. & Hartson, H. R. (1993). *Developing User Interfaces: Ensuring Usability through Product and Process.* John Wiley.

Holmes, W. P., Azam, M. A., Hills, P. C. (1995). A Preliminary Study of the relationship between Industrial Design and Engineering Design. *In Proceedings of DIS '95, Designing Interactive Systems*, ACM Press.

IMS Project, (1998). *IMS Meta-data specification*, (Online). Available via the WWW at http://www.imsproject.org/metadata/index.HTML.

Johnson, R. T. & Johnson, D. W. (1994). An overview of cooperative learning. In J.S. Thousand, R. A. Villa and A. I. Nevin (Eds.) *Creativity and Collaborative Learning.* Paul H. Brookes Publishing Company, 31-44

Johnson, R. (1996). Courseware Design Support. *Psychology of Programming Interest Group (PPIG)*, Volume 7.

Jonassen, D. H. (1989). Objectivism versus Constructivism: Do we need a new Philosophical Paradigm*? Educational Technology Research & Development*, 39 (3), 5-14.

Jonassen, D., Mayes, T., McAleese, R. (1992). A manifesto for a Constructivist Approach to Uses of Technology in Higher Education. *In Designing Environments for Constructive Learning.* Eds Duffy, T. M., Lowyck, J., Jonassen, D. H. Springer-Verlag.

Jonassen, D. H. (Ed.) (1998). *Instructional Designs for Microcomputer Courseware.* Lawrence erlbaum Associates.

Jones. J. C. (1992). *Design Methods.* John Wiley & Sons.

Karat, J. (1995). Foreword in Carroll, J. M., (Ed.), *Scenario-Based Design – Envisioning Work and Technology in System Development.* John Wiley & Sons.

Kelley, J. F. (1994). An iterative design methodology for user-friendly natural language office information applications. *ACM Transactions on Office Information Systems 2*, 1, 26-41.

Krathwohl, D. R. (1983). Foreword in C. Reigluth (Ed.), *Instructional-Design Theories and Models: An Overview of their Current Status.* Lawrence Erlbaum.

Laurillard, D. (1993). *Rethinking University Teaching: a framework for the effective use of educational technology*. Routledge.

Leigh, D. (1987). *A Brief History of Instructional Design*. (Online.) Available via WWW http://www.pignc-ispi.com/articles/education/brief%20history.htm.

Lowyck, J. & Elen, J. (1992). Hypermedia for Learning Cognitive Instructional Design. In *Hypermedia Courseware Structures of Communication and Intelligent Help*, Proceedings of NATO Advanced Research Workshop, 131-144.

McAteer, E., Hartland, M., & Sclater, N., (1996). De Tudo Um Pouco – a little bit of everything. Journal of Active Learning, 3, 10-15.

McInerney, D. & McInerney, V. (1994). *Educational Psychology: Constructing Learning*. Prentice Hall.

MacLean, A. & McKerlie, D., (1995). Design Space Analysis and Use-Representations. In Carroll, J. M., (Ed.), *Scenario-Based Design — Envisioning Work and Technology in System Development*. John Wiley & Sons.

MacLean, A., Young, R. M., Bellotti, V. and Moran, T. (1991). Questions, options and crtieria: Elements of Design Space Analysis. *Human Computer Interaction*, 6, 3 & 4, 201-250.

McCombs, B. S. (1986). The instructional system development (ISD) model: A review of those factors critical to its successful implementation. *Educational Communications and Technology Journal*, 34, 2.

McKavanagh, C. (2000) *Conversations in Vocational Educational Training*, Published in the proceedings of 1st Biennial International Conference on Technology Education Research, Gold Coast.

Mathers, B. (1998). *The use of HCI research techniques to guide the development of CAL for Strathclyde Fire Brigade*. Unpublished Honours project. Department of Computing Science, University of Glasgow.

Maturana, H., & Varela, F. (1987). *The tree of knowledge: the biological roots of human understanding*. New Science Library.

Mayes, J. T. (1995). Learning Technology and Groundhog Day. In Strang, W., Simpson, V. & Slater, D. (Eds.), *Hypermedia at work – Practice and Theory* in Higher Education. University of Kent Press.

Merrill, M. D., Li, Z., Jones, M. K. (1990). The second generation instructional design research program. *Educational Technology*, 30(3), 26–31.

Miller, S. (1996). *Experimental Design and Statistics*, 2nd edition, Routledge.

Moshman, D. (1982). Exogenous, Endogenous and Dialectical Constructivism. *Developmental Review*, 2, 371-384.

Murat, T. M. & Yeh, R. T. (1989) Editors' Introduction: Rapid Prototyping in Software Development. *IEEE Computer 22, 5, 9-10.*

Nelson, T. H. (1990). The right way to think about Software Design. In B. Laurel (Ed.), *The Art of Human-Computer Interface Design*. Addison-Wesley.

Newman, W. M., & Lamming, M. G. (1995). *Interactive System Design.* Addison Wesley Publishing Company.

Neilsen, J., & Mack, R., L., (1994) (Eds), *Usability Inspection Methods*. John Wiley & Sons.

Norman, D, A., *The psychology of everyday things*, London, MIT Press.

Norman, D. A., & Draper, S. W., (1986) (Eds), *User centered system design : new perspectives on human-computer interaction,* Hillsdale, Lawrence Erlbaum.

Page, J. K. (1966). *Building for People.* Conference Report. Ministry of Public Building and Works.

Pask, G. (1976). Conversational techniques in the study and praçtice of education. *British Journal of Educational Psychology*, 46, 12-25.

Piaget, J. (1970). *The Science of Education and the Psychology of the Child.* Grossman.

Phillips, R. (Ed.) (1996). *Developers Guide to Interactive Multimedia: a Methodology for Educational Applications.* Curtin University of Technology, Perth, Western Australia.

Polson, P. G., Lewis, C., Rieman, J. & Wharton, C. (1992). Cognitive walkthroughs: A method for theory-based evaluation of user interfaces. *International Journal of Man-Machine Studies*, 36, 741-773.

Preece, J. (Ed.) (1993). *A Guide to Usability – Human Factors in Computing*. Addison Wesley.

Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S. and Carey, T. (1994), *Human Computer Interaction.* Addison Wesley.

Pressman, R. S. (1994). *Software Engineering – a practitioner's approach.* McGraw Hill.

Psotka, J., Massey, L. D., & Mutter, S. A. (1988). *Intelligent Tutoring Systems – Lessons learned.* Lawrence Erlbaum.

Ramsden, P., (1992). *Learning to teach in Higher Education.* Routledge.

Reeves, A., Marashi, M., & Budgen, D., (1995). A software design framework or how to support real designers. *Software Engineering Journal, July, 1995*

Reswick, J., B. (1965). *Prospectus for Engineering Design Centre.* CASE Institute of Technology, Ohio.

Reigluth, C. M. (1983). Instructional design: What is it and why is it? In C. M. Reigluth (Ed.), *Instructional design theories and models: An overview of their current status.* Lawrence Erlbaum Associates.

Rice, M. P. (1989). *French Word Torture* (computer software). HyperGlot Company.

Romiszowski, A. J. (1981). *Designing instructional systems : decision making in course planning and curriculum design*, London, Kogan Page New York, Nichols Publications.

Rosenberg, D. & Hutchison, C. (Eds) (1994). *Design issues in CSCW.* Springer Verlag,

Ross, C. (1999). *The development of Web-based learning materials for Oxfam.* Unpublished Masters project. Department of Computing Science, University of Glasgow.

Royce, W., W., (1970). Managing the development of large software systems:concepts and techniques. Proceeding of IEEE Westcon, Los Angeles, 1-9 (9).

Sanderson, P. M.(1994). MacSHAPA and the enterprise of exploratory sequential data analysis (ESDA). *International Journal of Human-Computer Studies*, 41, 633-681.

Sanderson, P. M. & Fisher, C. (1994). Exploratory sequential data analysis foundations. *Human-Computer Interaction*, 9, 254-255.

Shneiderman, B. (1992) *Designing the User Interface – Strategies for Effective Human-Computer Interaction.* Addison Wesley Publishing Company.

Simon, H. A. (1981). *The sciences of the artificial* (2nd ed.). MIT Press.

Sims, R. (1995). *Interactivity: A Forgotten Art.* (Online.) Available via WWW http://129.7.160.78/intro.html

Skanshom, J. (1995). *Ada from the beginning.* Addison-Wesley.

Skinner, B. F. (1954). The science of learning and the art of teaching. *Harvard Educational Review*, 24(2), 86-97.

Sommerville, I. (1996). *Software engineering* (5th Ed.), Addison-Wesley Publications.

Tennyson, R. D., Elmore, R. L. (1995). *Integrated Courseware Engineering System in Automating Instructional Design: Computer-Based Development and Delivery Tools.* Springer.

Thorndike, E. (1921). *Principle of Learning.* Cambridge, Mass : MIT Press.

Tripp, S. D., Bichelmeyer, B. (1990). *Rapid Prototyping: An Alternative Instructional Design Strategy.* ETR&D, Vol. 38, No. 1, 31-44.

Tyler, R. W. (1975). *Educational benchmarks in retrospect: Educational change since 1915.* Viewpoints, 51(2),11-31

Utley, A. (1998). Heads resist CTI. In *Times Higher Education Supplement*, No. 1355.

Weaver, P. (1998). *Practical SSADM* version 5. Pitman Publishing Ltd.

Wiburg, K. (1995). *An Historical Perspective on Instructional Design: Is it Time to Exchange Skinner's Teaching Machine for Dewey's Toolbox*? (Online.) Available via WWW http://www-cscl95.indiana.edu/cscl95/wiburg.html.

Winn, W. (1989). Towards a rationale and theoretical basis for educational technology. *Educational Technology Research & Development*, 37, 35-46.

Winograd, T. & Flores, F. (1986). *Understanding Computers and Cognition.* Ablex Publishing Corporation.