Evaluation of the development and application of multimedia computer assisted learning in Higher Education

Volume I

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ABSTRACT

This thesis deals with approaches to the evaluation of multimedia computer assisted learning in higher education. The thesis is presented in two parts. The first part consists mainly of a literature based review of the rationale and methods employed in the development of multimedia CAL systems focusing on the ability of such systems to deliver a variety of pedagogic aims and objectives which the literature on the subject generally attributes to them. This was done in order to identify and examine the important features which should be incorporated in the effective evaluation of such systems.

- the pedagogical basis of multimedia learning environments with particular reference to the mechanism by which they claim to encourage an approach to learning which facilitates 'deep' rather than 'shallow' learning' (Chapters 3 and 4);
- the basis on which multimedia CAL systems claim to provide interactive learning environments which allow the teaching materials to be tailored by learners to accommodate their own individual preferences for adopting particular learning strategies. In particular this focused on the importance of individual learning styles and learners' degree of computer confidence (Chapter 5)
- the institutional/delivery factors which must be understood to explain fully the context in which evaluations are carried out and which may have important effects on the outcomes of evaluation (Chapter 6)

This literature review, together with a practical survey of a range of existing CAL courseware and an e-mail survey of CAL developers provides the basis for presenting an approach to evaluation which differentiates systems on the basis of the pedagogic approach they adopt and the context in which they are implemented. Finally, a critical review of existing evaluation methods was undertaken and important elements within these methods were incorporated into a new framework for evaluation. The framework provides a tool for determining an evaluation strategy that encompasses all stages of development, formative and summative evaluation of CAL courseware. Evaluation is based on the explicit aims and objectives of the courseware being provided and is moderated by contextual factors that define the pedagogical approach being taken, any individual learner differences that must be taken into account, and the institutional/delivery context within which the courseware is used. An analysis of the implications of the framework when formulating an evaluation strategy demonstrates weaknesses in the assessment instruments currently being used in evaluation studies - particularly for providing reliable measures of 'learning effect' as part of summative evaluation and also with respect to accurate quantification of costs associated with development and use of CAL courseware.

The second part of the thesis tests the framework. The approach taken was to develop and formatively and summatively assess a multimedia CAL system used to teach parts of a course on bibliographic classification to students at the Robert Gordon University in Aberdeen. Qualitative and quantitative tests to accomplish this are described and the result of statistical analyses of learner performance when using the system are presented. This empirical study provides further insights into the practical problems involved in developing and evaluating a multimedia CAL system and in particular highlights:

- the influence which individual learning style (as measured by the Gregorc Style Delineator) has on student performance in a context in which postgraduate students were required to use

the CAL courseware rather than attend lectures. Results indicate that CAL does not serve all learners equally, and;
- the importance of the delivery context in a study in which undergraduate students were provided with CAL materials to supplement the delivery of their course.

The evaluation framework was found to be a robust framework for developing and testing didactic teaching packages which were developed in the context of improving the quality of the teaching and learning of bibliographic classification to both undergraduate and postgraduate students. Recommendations are provided for future research based on using the framework to explore other contexts in which courseware is developed and implemented.

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CONTENTS

CHAPTER ONE: Introduction and Background

PART 1 – LITERATURE REVIEW AND DEVELOPMENT OF FRAMEWORK for EVALUATION

CHAPTER TWO: Methodology – Literature Review and Development of Evaluation Framework

CHAPTER EIGHT EVALUATION METHODOLOGIES AND MODELS

PART 2

CHAPTER NINE – Development of Prototype CAL Package

CHAPTER TEN Formative Evaluation

CHAPTER ELEVEN – Summative Evaluation

CHAPTER TWELVE – Summary and Conclusions

FIGURES

TABLES

APPENDICES

Chapter One

Introduction and Background

> *'If a man were to begin with certainties, he shall end with doubts, but if he will be content to begin with doubts, he shall end in certainties'*
>
> ***Francis Bacon. The Advancement of Learning***

1.0 Introduction

Almost since the birth of the digital computer, educators and educational technologists have concerned themselves with the potential role of the new technology in education. In particular, in higher education from the beginning of the 1990s there has been a substantial growth in interest and activity in the development of computer assisted learning (CAL) and a large literature has developed which claims to provide generalisable conclusions about the efficacy of CAL applications (Nelson and Palumbo, 1992; Hawkridge, 1995; Liu and Reed, 1995; Burbules and Callister, 1996). Stimulated by the capability provided by enhanced computing technologies and encouraged by the interest of government (in particular in funding application of these technologies) there has been an explosion of applications and developmental work in this field. The development of multimedia authoring systems and the consequent ability of CAL system designers to integrate a variety of different types of media into applications, to design more attractive end user interfaces and to provide a highly interactive approach to using such information, has further encouraged interest in CAL development. Many authors have contended that CAL software continues to improve in its ability to provide realistic and stimulating learning environments. (Price, 1991). Thus, in the recent past, multimedia authoring systems have been used extensively to produce a large body of 'courseware' for use in higher education. Learners and instructors are able to choose from a variety of educational software packages designed to augment the curriculum (Dwyer, 1996). In particular, rapid growth within the higher education sector in the United Kingdom has been prompted by a number of national initiatives, notably the Teaching and Learning with Technology Programme (TLTP). Such initiatives have specifically aimed to increase the level of high quality software. CAL courseware is now available for a wide range of subject areas and audiences, but all developments share the common assumption that information presented in an interactive multimedia format can help to deliver parts of the higher education curriculum more efficiently and/or effectively. This thesis examine the basis for some of the claims made for multimedia CAL and in particular seeks to appraise critically the context in which the different key features of CAL courseware must be defined and evaluated to ensure that CAL interventions achieve their stated objectives in terms of enhancing the quality of learning or the effectiveness of teaching. This analysis forms the basis for a framework for evaluation that provides a means of assessing the outcome of these innovations in teaching and learning in higher education. The evaluative framework for assessing computer assisted learning is inextricably interwoven with practical considerations related to the environment in which higher education is currently being delivered, the pedagogic benefits which multimedia CAL packages claim to provide or support, and the attitude and receptiveness of students to technology based learning.

1.1 Research Problem

There is an acknowledgement generally in the literature that for any development or innovation in teaching methods in higher education there is both an external and internal demand to perform some form of evaluation. However, there are a number of different reasons for engaging in this activity. Such considerations are typically predicated by a need to show that new developments are cost effective, that the outcome of the development 'works' in terms of delivering educational objectives, that the development is acceptable to students as an alternative to other types of educational intervention or that it improves the quality of learning. However, attempts to plan studies in order to demonstrate any of these prove to be problematic. In order to assess the value of any educational intervention a complex network of factors has to be taken into consideration. In reviewing the literature it is apparent that a major problem with studies which seek to look at the value of computer assisted learning is that they examine only one or two factors and fail to adopt an holistic approach to determining the overall benefit of the package being tested. Often this is because of a failure to understand fully the complexity of evaluation and of the need to clearly define the purpose of the evaluation in relation to the objectives for which the CAL package was developed or is being implemented.

In this respect, the purpose of this thesis is to provide a better basis for teachers and administrators in higher education to make informed decisions on development or selection and implementation of multimedia CAL systems. Specifically the research is concerned with examining the question of how to test the claims that multimedia CAL systems can improve the quality of learning in higher education. In order to do this, while avoiding the fragmented approach that is typical of many of the studies of CAL which have been conducted to date, it is essential to develop a framework for evaluation based on all of the factors that are likely to influence the acceptance of computer based educational interventions.

Broadly the different factors which may potentially influence the manner in which the impact of CAL on learners must be considered can be separated into issues which are based on:

1. the design of the system itself;
2. the content of the package and context in which it is used;

and

3. the pedagogic approaches adopted.

For this reason, it is generally recognised that it is necessary to carry out a number of different types of evaluation of new educational resources. These evaluations should examine issues associated with the design of the educational software itself (formative evaluation of the resource) in order to investigate ways of improving the resource itself or the manner in which it should be introduced to students. Evaluations are also required which allow us to summarise the effect of the introduction of the resource and investigate issues that relate to the manner in which the resource has had an impact on learning (summative evaluations). Such investigations can provide a clearer picture of how students learn with technology and highlight the positive and negative aspects of this interaction in order to help us to design more robust educational technologies and understand more clearly the circumstances in which they can be appropriately deployed.

Another consideration in evaluation is that it is important to be aware that the evaluation can be influenced by the environment in which the system is introduced. This manifests itself at two levels:

- the 'macro level' at which a broad range of political, social and economic factors which impinge on and influence the delivery of teaching have to be considered

and

- the 'micro level' at which conditions related to the particular environment in which CAL material is delivered have to be examined

At the 'macro level', therefore, to understand fully the issues related to how CAL has been evaluated within universities in the United Kingdom over the past decade it is necessary to consider some of the broader initiatives in teaching and learning which have supported the development and implementation of CAL in the higher education curriculum. In particular, it is important to look at the broad objectives relating to the manner in which the higher education curriculum is delivered which has prompted most of this activity.

At the 'micro level' it is important to identify all the variable factors that may be pertinent to the particular situation in which CAL has been introduced. This includes, for example, the type of teaching task which the CAL material is supporting or replacing, how it is introduced to students, the availability of suitable equipment and technical support when it is being used. It also includes, of course, variables which may be specific to the particular group of students who are evaluating the materials. The main factors included in this category are background skills in use of technology (and in particular previous exposure to CAL), the attitude of students to the course of study and the mode of delivery, social and personal circumstances of individual students and the preferred learning style of students. This latter category is particularly important when considering an evaluation of courseware which seeks to improve learning as it is necessary when conducting an evaluation to ensure that the educational intervention is of benefit to all students or at least to identify explicitly the circumstances in which individual learners may be disadvantaged. Thus an important part of evaluation should be ensuring that individual learner differences are accommodated. This is a particularly important issue in technology based interventions where there is fairly conclusive evidence that individual learners' attitudes to working with computers and processing information effectively using computer interfaces differs considerably from their reaction to 'traditional' oral and written presentations (Bright, 1983; Clement, 1981; Dillon, 1990). Thus evaluation is complicated not only because of the large number of variables which are involved in assessing the perceived 'value' of a new educational intervention but also because the introduction of a new piece of educational software will itself have an impact on the environment in which it is being introduced and in particular the manner in which students view their educational experience.

There are, therefore, a number of different reasons for developing computer assisted learning programmes as well as a range of factors which may mitigate for or against their success. This has led a number of authors (Draper, 1996; Milne and Heath; 1998) to stress the need to be very clear about the purpose of the evaluation in general. Moreover, it is of critical importance to contextualize the evaluation strategy adopted for a particular system with the overall purpose or rationale for introducing that system. Thus specific objectives for particular implementations of CAL must be clearly defined. If such objectives are not defined the evaluation will not be able to focus on what the intended outcome of using the CAL package is and inevitably, although it may result in the provision of some general statements concerning the perceived usability and usefulness of the package it cannot provide a true measure of effectiveness.

The research problem, therefore, is concerned with the need to synthesize a whole range of issues to develop an effective framework which will provide a better basis for making a realistic assessment of the value of developing and using multimedia CAL in higher education. The primary purpose of this framework to act as a tool that can be used to determine whether or not CAL fulfils its objective of improving quality of teaching and learning in higher education.

1.2 Aims and Objectives

The aims of the research arise out of the research problem described above.

1.2.1 Aims

The research aims were

- to create a framework for evaluating multimedia CAL systems which specifically addresses the issue of determining the validity of claims that such systems enhance the quality of teaching and learning in higher education
- to develop multimedia CAL courseware to provide a tool for testing the validity of claims made in the literature relating to the benefits of multimedia CAL and to examine in detail (and from the learner's perspective) the mechanisms by which such systems support student learning
- to test the framework for evaluation by using it to evaluate the courseware package developed as part of the research programme and, as a consequence of following that framework, to investigate the extent to which the multimedia CAL system supports all learners equally by examining the influence of individual differences between learners on their perception of CAL systems and their performance in using it in an authentic learning environment

1.2.2 Objectives

In order to develop a framework for the evaluation of CAL it was firstly necessary to identify and appraise critically the rationale for development of multimedia CAL packages designed to be used in higher education. An examination of the manner in which it is claimed that such systems are able to meet the objective for which they were designed i.e. of improving the quality of teaching and learning in higher education is necessary before it is possible to develop a framework for evaluating such systems. This was accomplished largely from an analysis and synthesis of the literature that describes multimedia CAL developments and the educational theory which underpins this work. The development of the framework for evaluation was also informed by a practical examination of multimedia CAL systems themselves and a critical appraisal of existing and proposed evaluation methodologies again derived from the literature.

Thus in order to achieve the first aim given above the research pursued the following objectives:

- to review critically the literature to determine the basis on which multimedia CAL has been developed and evaluated in higher education;
- to review critically the claims made for hypermedia/multimedia CAL as a teaching tool;
- to set these claims in the broader context of models which seek to define the important characteristics, aims and objectives of higher education;
- to review existing evaluation methodologies and synthesise these to develop a framework which describes and analyses the relative importance of different contextual factors which influence the effectiveness of multimedia CAL in higher education and the circumstances in which such factors need to be considered.

The development of the evaluation framework was complemented by a practical investigation involving the creation and evaluation of a multimedia CAL package. There are a number of claims made about how CAL 'improves' learning but some of these – in particular those related to the importance of use of different media and degree of learner control – have been challenged by a number of authors. (Clark, 1985; Reeves, 1993). Likewise there are a number of issues surrounding the expectations which students have of CAL environments and their concerns about how such systems are implemented. It was considered that such issues could profitably be investigated by developing a system and using this as a focus to engage students in discussing problems which were both specific to the system and more general to CAL itself. The computer assisted learning package was developed to deliver practical and theoretical aspects of a course of study in the field of bibliographic classification. This is a subject area that is currently taught to both undergraduate and postgraduate students registered on courses in Information and Library Studies in the School of Information and Media at the Robert Gordon University. Using this package a number of empirical tests have been undertaken which directly focus on the manner in which learners react to and interact with computer assisted learning technology. This provided a more detailed picture of how students themselves evaluate and use CAL material than would have been possible from conducting a purely literature based approach.

Thus in order to achieve the second aim given above the research pursued the following objectives:

- to develop a CAL package designed to support the teaching of parts of a unit in bibliographic classification;
- to use the CAL package to investigate claims made in the literature about inherent benefits of CAL courseware;
- to use the CAL package to investigate the influence of key issues relating to student perceptions and background attitudes to using CAL materials and the manner in which students learn using CAL.

Finally the third aim of the research was to test the framework for evaluation by using it to evaluate the courseware package developed as part of the research programme. Much of the previous research in this area of CAL evaluation has been conducted from the perspective of the student cohort as the 'subject' of the experiment. The research undertaken at this stage (in accordance with the framework for evaluation) started from the hypothesis that it is important to investigate the manner in which individual students interact with technology based learning and their perceptions of its value. Thus, when testing the courseware developed as part of the research, rather than concentrating narrowly on providing performance assessment measures that seek to establish a change in knowledge and understanding, a more holistic evaluation was undertaken which aimed to establish the potential of CAL to improve the quality of learning for all students. The literature suggests a number of variables which may be important in explaining difference in receptiveness to use of CAL software by learners and this is discussed in detail in Chapter Five. The empirical research presented here was primarily concerned with investigating the importance of learning styles.

Thus in order to achieve the third aim given above the research pursued the following objectives:

- to apply the framework for evaluation by formatively and summatively evaluating the CAL package developed as part of the research
- to investigate methods of determining student learning styles

- to apply an appropriate instrument to measure student learning style (in this case the Gregorc Learning Style Delineator) and investigate the correlation between learning style and performance with, and attitude to, using CAL

The evaluation framework takes an holistic view of multimedia computer assisted learning from the viewpoint of all of the important stakeholders. The framework should allow both those who develop and those who apply multimedia CAL applications to make more informed judgements of the context in which such materials should be developed and used and the basic parameters within which we can measure their usefulness. In addition, through practical work in developing a CAL package and using the evaluation framework to test it, the research adds to our knowledge in the crucial area of student attitudes towards computer assisted learning and identifies important barriers which must be removed in order to integrate CAL into the curriculum.

1.3 Definitions

The whole area of multimedia developments and computer assisted learning is fraught with acronyms and problems of definition. The following section seeks to establish the parameters within which various terms have been used throughout the thesis and to provide clear guidance on how terms have been interpreted.

1.3.1 CAL - Computer Assisted Learning

Computer assisted learning (CAL) has been defined as:

> *'a generic or umbrella term that is used to describe collectively the various, teaching, training and learning activities associated with or based on the computer.' (Queen's University Belfast, 1998, Online).*

This definition is also employed by the University of Southampton Computer Based Learning and Training department who emphasise the fact that:

> *'... it also encompasses the teaching of how to use a computer - IT skills'. (Southampton University, 1998, Online).*

It is important to note that a more restricted use of the term is adopted in this thesis and CAL (or its various synonyms)[1] will be taken to mean the use of the computer to deliver a course or part of a course of instruction in the higher education curriculum. The focus of discussion is therefore on *courseware* - a term used to mean instructional material designed for delivery using a computer. A full discussion of the definition of CAL and a variety of what are seen as synonymous terms is provided by Rist and Hewer in the context of their discussion and definition of learning technology. (Rist, 1996). In the context of the work undertaken here it is also important to make a clear distinction between learning (CAL) and computer based training packages (CBT). Riley provides a crude distinction between learning and training as being concerned with 'why' and 'how to' respectively and whilst there is doubtless much more to the issue than this, the points he makes on the distinction of approach to be adopted in development terms is valid (Riley, 1995). Kearsley and others, whilst attempting to draw distinctions between the various systems, have focused on subject matter and methodologies employed in the CAL packages.(Kearsley, 1995). However, more accurate differentiation can be made by looking at the objectives of the systems rather than the means by which these objectives are achieved. Whilst there is a clear similarity in the methods employed to create teaching and training material, the aims and objectives in terms of learning outcomes differ substantially and, as the experience of developing the CAL packages (described in Chapter 9) demonstrated, it is these which prompt the marked difference in the consideration of software design and user interface design involved in both approaches.

Currently there is a convergence of communication and computing technologies and the majority of CAL products are now designed to be delivered using the World Wide Web. This not only makes access to the packages easier, it also allows the development of much more direct channels of communication with students using such systems. This thesis, whilst not differentiating the delivery medium used, focuses on the evaluation of issues concerned with the courseware itself

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1. There are many other acronyms used to describe use of computers in education. A large number of terms used very imprecisely to refer to computer assisted learning. Such terms include CBI, CBT, CBL, CEI, CET, CEL, CAI, CAT, CAL, CMI, CAT, CMT, CML, TBL, TBT, TBI - essentially, in such acronyms the C refers to Computer, B to Based, E to Enhanced, A to Assisted or Aided, M to Managed or Mediated, I to Instruction, T to Training and L to learning. To further complicate matters the terms are used inconsistently within American and British publications, the former tending to favour the term instruction rather than learning.

rather than the more general issues related to computer mediated communication and distance learning delivery. Thus the thesis is primarily concerned with stand alone CAL applications.

1.3.2 Multimedia

Definitions of multimedia given in the literature vary enormously and there has in the past been some confusion which is evident in the production of partial definitions which set about defining the technology, defining the impact of the technology or defining the context in which the technology is used. Examples include the following 'definitions' or rather attempts to avoid definition, provided by editorials in the periodicals *Byte* and *Multimedia:*

> *'Even if you're not sure what multimedia is, you probably know it when you see it (or hear it)...' (Robinson, 1990, p.265)*

or

> *'... a singular mix of disparate technologies with overlapping applications in pursuit of a market and an identity' (Multimedia: computing with sound and motion., 1990, Editorial)*

A literal definition of multimedia is that the term refers to the use of two or more different information media. These media may be text, sound, video or graphics. Feldman, however, provides a more succinct and useful definition which is the one adopted here when he notes that:

> *'Multimedia is the seamless integration of data, text, images of all kinds and sound within a single, digital information environment'. (Feldman, 1994, p.16)*

More simply and directly Kommers (1996) notes that multimedia can be defined as:

> *'Computer based applications that allow the user to see and hear different types of information via one screen with audio support' (Kommers, 1996, p.2)*

These definitions highlight the fact that these media should be presented on a single computer platform. In fact the bulk of the development work has centred around the use of the IBM-PC and Apple Macintosh. The investigation of multimedia courseware has thus concentrated on these platforms and has not considered in detail applications which are, for example, built around the use of CD-I (Compact Disc Interactive) or interactive videodisks.

There is some confusion in the literature over the distinction between the term multimedia and the term hypermedia. Hypermedia is used to refer to the manner in which the digital content is organised into *nodes* which represent *'chunks'* of content and *links* which provide associations between the nodes. The links are created by the author of the multimedia package and the user is generally free to explore the information presented in a non-sequential manner, following or ignoring links in an exploratory fashion. Typically multimedia CAL packages are developed as hypermedia systems, and indeed, it is the interactivity which is afforded by the flexible use of a web of nodes and links which is generally assumed to provide many of the pedagogical benefits associated with these developments (Ambron, 1990; Barker, 1993; McKnight, 1993; Alpert, 1995). Nielsen (1995) attempts to differentiate the terms 'hypermedia' and 'multimedia', claiming that the former are based on hypertextual principles and the latter use a variety of media without hypertext links. A full and fairly complex discussion of terminology and definitions is provided by Tolhurst. (Tolhurst, 1995). Evans and Edwards (1996) further complicate the issue by seeking to draw a distinction on the basis that hypermedia systems provide implicit navigation whereas multimedia environments provide explicit navigation (concluding, therefore, that multimedia systems are more appropriate for learning environments). Such distinctions, however, are overly complex and do not reflect any real differentiation made in practice or in the general use of the terms in the literature. Thus the terms multimedia and hypermedia will be used interchangeably within the context of Feldman's definition given above.

1.3.3 Evaluation

A dictionary definition of evaluation is that it is a process conducted to: 'ascertain or set the amount or value' (Collins, 1979). Value is defined in the same source as

> *'the desirability of a thing, often in respect of some property such as usefulness or exchangeability : worth, merit or importance'. (Collins Dictionary, 1979)*

However, in practice, the term evaluation is often used to cover a variety of activities. Draper makes a distinction between 4 types of evaluation - formative, summative, illuminative and integrative (Draper, 1996). The following section summarises these definitions but it should be noted that, in the light of analysing the literature in the field, the definitions provided here differ somewhat from those presented by Draper.

The main role of *formative* evaluation is to improve the CAL resource itself by ensuring that the resource works as planned or performs to specification, and identifying potential for improvement in the design or implementation (Scriven, 1967). To a certain extent this can be seen as the simplest form of evaluation to conduct although the planning for formative evaluation poses logistical problems because if conducted thoroughly it considerably increases the development time for multimedia CAL. However, if it is not given sufficient consideration there can be serious consequences for subsequent stages in evaluating courseware. There is, in particular, the danger that subsequent evaluation may be biased disproportionately because of considerations of the design and content rather than the extent to which the CAL material achieves its central objective in teaching. There are a number of works which describe the process of formative evaluation and offer useful guidelines on how it should be conducted (West, 1991; McAteer and Shaw, 1994; Riley, 1997; Boyle, 1997).

The definition of *summative* evaluation is not so clear from recent literature and needs more careful examination. Davidson, for example, echoing the discussion on evaluation typologies by Draper (Draper, 1996) asserts that:

> *'Summative evaluation is generally carried out after the software has been produced and to help users choose which piece of CAL to use and for what.' (Davidson et al., 1998, p.5).*

A more widely held definition (and one which accords more closely with the use of the term by Scriven who is generally credited with the introduction of the terms formative and summative evaluation (Scriven, 1967)) is provided by Laurillard who contends that summative evaluation:

> *'Describes the evaluation of course materials that provides information on the success or otherwise of the implementation of these materials, possibly in comparison with alternative teaching methods.' (Laurillard, 1993, p.240).*

This is the definition that is adopted within this work and implies a more general rôle for summative evaluation than that assigned by Draper. However, it does raise the question of how 'success' is to be measured. Laurillard is justifiably cautious when she asserts that comparative evaluation with other teaching methods is only one possible method that can be used to evaluate success. It is in looking at other possibilities and attempting to provide an answer to the question of how success can be measured that Draper and the TILT (Teaching with Independent Learning Technologies) group's work on illuminative and integrative evaluation is particularly significant. Strictly speaking these types of evaluation are broadly subsumed under the above definitions of formative and summative evaluation. However, it is useful to consider these categories separately because they represent significant issues and approaches which must be considered when conducting an evaluation of any educational intervention.

Illuminative evaluation refers to an approach which stresses the need to take into account the opinions, pre-conceptions, and perceptions/misperceptions of students using the CAL material. It is clearly outlined by Parlett, who introduced the term, and it is particularly important because it draws attention to the fact that the focus for evaluation must be based not only on the outcome of a particular test but on the manner in which students used the CAL material (Parlett & Dearden, 1977; Parlett & Hamilton, 1987). The approach can be seen to be based on phenomenographic methodologies, the conceptual framework of which focuses on the experience of learning from the student's perspective.

As Marton explains:

> *'our task is thus to describe more clearly how learning takes place in higher education and to point out how teaching and assessment affect the quality of learning. From these descriptions teachers should be able to draw their own lessons about how to facilitate their students' learning' (Marton, Hounsell & Entwistle, 1984).*

Thus the application of illuminative evaluation revolves around the need to understand the approaches taken by students to learning with CAL rather than simply the results they achieve. As Draper explains:

> *'Its importance is as an open-ended method that can detect what the important issues are, without which other methods often ask the wrong questions and measure the wrong things.' (Draper, 1996, Online)*

Viewed in this light it is possible to define illuminative evaluation as being an important component of both formative and summative evaluations if the objective of the evaluation is to do more than simply provide a 'scientific' measure of whether or not a piece of courseware fulfils its objectives. Illuminative evaluation is particularly valuable during the formative stage of courseware development because it allows courseware designers to examine in more detail the mechanism by which the courseware works and provides useful information on the processes involved in learning.

"*Integrative evaluation*" is a term which has been coined to define an approach to evaluation which has evolved as part of the TILT programme at Glasgow University. The TILT group report *'Observing and measuring the performance of educational technology'* questions standard use of the term 'evaluation', which implies making a (value) judgement and goes on to state that

> *'a better statement of our [the TILT] group aims is to "discover how it performs" i.e. to gather information to support judgements rather than making them' (Draper, 1994, p.5).*[2]

This approach has arisen out of the extensive work that has been done on classroom studies of CAL and places emphasis on the manner in which CAL is used in any given situation. In part the approach has evolved in response to a perennial concern in educational research i.e. the problem of integrating theory and practice. By focusing very much on factors which influence the use of CAL in practice, the use of integrative evaluation claims to detect important issues which may influence the outcome of summative evaluation. In particular integrative evaluation allows the researcher to examine in detail the way in which CAL has been implemented and the manner in which it impacts on and is influenced by existing teaching methods and practices. It has the potential, therefore, to encompass the overall teaching and learning situation within the evaluation, and addresses an important issue which may not be considered in the other types of

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[2] *It should be noted, however, that this does not clarify how these judgements are to be made, nor who is to make them.*

evaluation discussed thus far i.e. the importance of the local environment to the outcome of using particular CAL materials.

It is only when used collectively that these various forms of evaluation can provide an accurate picture of the value of particular multimedia CAL packages. They will provide evidence not only about performance changes which can be attributed directly to the use of a particular package but also on how the package effects these changes and any environmental considerations which impinge on the change in performance which has been observed. All of these considerations are important if we are to be able to establish a benchmark standard for comparison of different CAL packages or for measuring the success of CAL against 'traditional' forms of delivery of higher education.

A useful overarching definition of evaluation is provided by Stern whom Jackson quotes (Jackson, 1998) as stating that:

> *'Evaluation is any activity that throughout the planning and delivery of innovative programmes enables those involved to learn and make judgements about the starting assumptions, implementation processes and outcomes of the innovation concerned' (Stern, 1988,Quoted in Jackson, 1999, p.22)*

Although one could quibble with the restriction implied by the use of the word 'innovative' this definition is broad enough to cover the various evaluation types described above and accurately reflects the holistic approach to evaluation which is adopted in this thesis.

1.3.4 Education

Again a dictionary definition of education provides us with a starting point for discussing the parameters which have been used when referring to education within the context of the thesis. Collin's Dictionary of the English Language defines education as 'The act or process of acquiring knowledge, esp. systematically during childhood and adolescence.' (Collins, 1979). However, there are few commentators who would take such a restricted view of the process of education – and certainly not as it applies to higher education. (The investigation here has been confined to Higher Education which in the United Kingdom is taken to refer to courses offered at degree level by universities). There has been considerable debate in the literature on what is meant by ‘education’ in this context. The debate revolves mainly around the type of learning which takes place in higher education and which characterises the essential purpose of education at this level. Saljo attempts to provide a typology of learning in Higher Education (Saljo, 1979) and provides five fundamental responses which represent (singly or collectively) different individuals’ perceptions on what is involved. These, he summarises, as:

1. a quantitative increase in knowledge;
2. memorizing;
3. acquisition of facts, methods etc. which can be retained and used as necessary;
4. the abstraction of meaning;
5. the interpretation process aimed at understanding reality.

Marton later added a sixth response to this definition (Marton et al., 1993)

6. developing as a person.

Other authors, notably Entwistle, Ramsden, Pask and Laurillard, have attempted to provide a broad definition or framework for higher education. It is important to examine such frameworks when considering the potential benefits of CAL because it is only in the context of a well-defined model of what the aim of teaching and learning is that we can begin to determine whether ‘technological solutions’ are appropriate. As Draper notes,

> *‘we need a model of the teaching and learning process in order to be aware of the main factors having a considerable effect on whether students learn’ (Draper, 1994, p.14)*

The model adopted in this thesis is Laurillard’s conversational framework (discussed fully in Chapter 6). There are some problems in applying this model to collaborative learning environments that are now becoming much more prominent because of developments in the use of the Internet to deliver courses in Higher Education. However, the model is valid for the purpose of defining processes and activities in stand alone CAL applications and those are the types of application with which this thesis is primarily concerned.

There is a considerable body of material available on multimedia CAL systems that have been developed for use in the business and commercial sector and an even larger body of material on the use of multimedia in primary and secondary education. Such material has been referred to only when it deals with generic considerations and reports conclusions that have applicability within the context of teaching and learning in higher education.

1.4 Overview of the Thesis

The thesis is presented in two main sections. The first part *(Chapters 2-8)* is, to a large extent, concerned with the aim of critically appraising the literature and developing a framework for evaluating the use of CAL in higher education. The second part of the thesis *(Chapters 9-12)* presents an empirical study involving the development and evaluation of a CAL resource using the framework for evaluation developed in the first part of the thesis. The CAL package was also used to conduct a variety of tests in order to gain a deeper understanding of issues relating to student attitudes to CAL and in particular to examine the impact of a key variable – learning style – on individual learners' attitudes to and performance using CAL software. The methodologies applied in deriving the evaluation framework and in using the framework to develop and test a CAL package have been presented separately. However, it should be noted that in terms of the progress of the research there is not a strict delineation between practical developments and testing, and the formulation of the framework for evaluation. Indeed, the development of the evaluation framework was informed to some extent by the practical issues and problems which were encountered when developing the CAL package.

1.4.1 Chapter 1 Introduction and Background

The main objective of chapter one has been to define the research problem, describe the scope and limitations of the research being undertaken and to introduce the main themes that characterise the manner in which the research has been conducted. It also presents an overview of how the thesis is organised.

1.4.2 Chapter 2 Methodology. Literature Review and Development of Evaluation Framework

This chapter provides an overview of the methodological approach that was adopted in the first part of the thesis.

1.4.3 Chapter 3 Computer Assisted Learning – Behaviourist Approaches

The third chapter examines in detail the features of, and claims made for, CAL. The chapter provides an historical perspective on the development of CAL and critically examines the rationale for using computers in teaching. This is presented in the context of an examination of the pedagogical relevance of CAL approaches and in particular concentrates on an examination of the behaviourist approach to learning which many of the earlier developments in CAL overtly or implicitly supported. A model of the main issues involved in development of CAL packages based on this approach is then presented.

1.4.4 Chapter 4 Multimedia Computer Assisted Learning – Cognitive Approaches

The fourth chapter consists of a discussion of the claims made specifically for multimedia CAL. Again the claims for benefits which are potentially accrued from use of multimedia CAL courseware are examined in the light of pedagogical theories which it is claimed underpin development of such systems. In particular the claims made in relation to the pedagogic effectiveness of the use of more than one medium and the ability to incorporate a high level of interactivity in CAL are examined. The model for development of effective multimedia CAL packages is enriched to take into account the factors which are implicit in adopting a cognitive approach to designing such packages.

1.4.5 Chapter 5 Individual Differences

One of the main features of computer assisted learning packages is their ability to accommodate a variety of approaches to learning. The objective of chapter five therefore is to review research into a range of factors related to inidividual learner differences which have a potential impact on student reaction to and use of CAL systems. Again the evidence from the literature regarding the manner in which considerations of individual learner differences should inform the development of CAL is incorporated into the model of CAL development which has been built up in the preceding two chapters.

1.4.6 Chapter 6 Institutional Context and Educational Framework

Multimedia CAL applications are often described in the literature as rich learning resources. However, in order to evaluate how these resources perform in delivery of the curriculum in higher education it is important to understand the aims of the educational framework in which they are being implemented. The sixth chapter looks at the development of models of teaching and learning in higher education with specific emphasis on the way in which educational technology is viewed as having a potential to make an impact. The discussion in this chapter includes a review of the social, technological and political environment in which such developments have been framed in order to develop a clearer picture of all of the factors which are influential in the methodologies which have been developed for evaluating multimedia CAL.

1.4.7 Chapter 7 Survey of multimedia CAL packages

In a practical area such as courseware development it is obviously important to look not only at the description of CAL packages as presented in the literature but also to examine the systems themselves in order to determine how closely the theoretical principles advocated in the literature have been implemented in practice. This has been done by reviewing a large number of CAL systems and using this as the basis for developing a rough taxonomy of CAL packages based on pedagogical objectives. This was instrumental in highlighting the main points at which the 'ideal' system as described in the literature differs from many practical examples. In order to provide a less subjective view of current CAL packages it was also important to incorporate a survey of attitudes and practices of developers of CAL products for higher education. This was done by conducting an e-mail survey of developers of CAL applications. The survey sought to discover more detail about the extent to which CAL products have been developed and evaluated. In particular it sought further information on the pedagogical basis behind the design of CAL packages, clarification on how the developers had conducted evaluation and the basis on which 'success' has been determined. (Note that because of a poor response rate from developers a follow up telephone survey was conducted which targeted particular individuals who were known to have been actively involved in producing multimedia courseware for higher education)

1.4.8 Chapter 8 Evaluation Methods and Methodologies

The eighth chapter examines evaluation methodologies which have been suggested and employed for assessing the effectiveness of multimedia CAL. In particular the chapter examines the debate surrounding the use of quantitative methods and comparative studies and the move towards evaluation which is more concerned with affective considerations. These are discussed in relation to the broader aims for teaching and learning using technology which have been discussed within Chapters 3 to 7. Throughout these chapters the information derived from the literature is analysed in order to build up a model for development of CAL applications. This model incorporates all of the reasons which have been put forward for developing and using CAL and thus provides an essential basis for developing a framework for evaluating CAL. The evaluation framework incorporates all of the factors which have to be considered to fully evaluate all aspects of developing and implementing CAL effectively and integrating it into the curriculum. The framework for evaluation in addition provides guidance on how an evaluation strategy will be influenced by three key contextual factors (delivery issues, pedagogical objectives and learner differences) all of which must be explicitly defined when formulating specific educational 'peformance' objectives for particular CAL systems.

1.4.9 Chapter 9 Development of 'CLASSICAL'

The ninth chapter marks the beginning of the second part of the thesis which concentrates primarily on findings related to evaluation which have been gained through a practical study involving the development and testing of a demonstrator multimedia package.

The ninth chapter outlines the methodology employed in the development of a prototype CAL system (CLASSICAL) intended to support the research by permitting a more detailed examination of how evaluation should be conducted in practice and to gain insights into the manner in which students learn using CAL. The chapter discusses how the development process fits in the framework for evaluation described in Chapter Eight and relates the experience of development to the literature on the subject.

1.4.10 Chapter 10 – Formative Evaluation

Chapter ten discusses the formative evaluation of the CAL system and an empirical study describes a range of surveys and experiments that were used when creating and testing the CAL package. This chapter explores in detail the particular concerns of students both at the stage at which the packages were being constructed and in subsequent trials using the software to ensure that the material was arranged and presented in a logical manner and that the interface was easy to use. The formative evaluation was not only focused on the robustness of the system itself but was also concerned with students perceptions on the use of CAL to deliver parts of the curriculum (and thus the tests could more precisely be termed as providing illuminative evaluation). This chapter includes analyses of data gathered from students over a period of four years and provides a very rich source of information on the concerns which users have about CAL generally as well as specific concerns about the particular package which was being developed.

1.4.11 Chapter 11 – Summative Evaluation

Chapter eleven details the summative tests conducted in conjunction with 'live' use of the CAL package by a cohort of postgraduate students and a cohort of undergraduate second year students. Using the framework for evaluation developed in Chapter Eight a number of research questions and hypotheses are created and these are the basis on which summative evaluation of the CAL package was undertaken. The purpose of the summative evaluation was not only to determine how effective the package was in comparison with more 'traditional' forms of delivery (in lectures and practical classification seminars) but was also concerned with finding out more about the influence of key learner variables on this performance. This was done in order to investigate whether the CAL material was equally beneficial for all users. Examining the manner in which students used the system (provided by online tracking of their actions) and their performance in an on-line test were correlated with gender, age, attitude to computer assisted learning, and individual learning styles.

1.4.12 Chapter 12 Conclusions

The final chapter of this thesis draws together the findings from both parts of the research and discusses what has been learnt from the work that has been undertaken. It also points to what might be discovered from further investigation and suggests some possible avenues for future research.

1.5 Overview of Structure of Thesis

Figure 1.1 (below) shows the sequential progression of the major themes developed in the thesis. In the first part of the thesis the discussion on behaviourist and cognitivist approaches to learning using multimedia CAL are instrumental in providing a clear understanding of the pedagogic arguments which are used to support the development of multimedia CAL. This is an important factor in developing a useful classification of multimedia CAL systems. This is necessary because the objectives of the CAL systems themselves have a defining influence on how the systems should be evaluated. Whilst there are other factors which have to be considered when performing an evaluation of CAL, the claims made for their effectiveness as tools to support

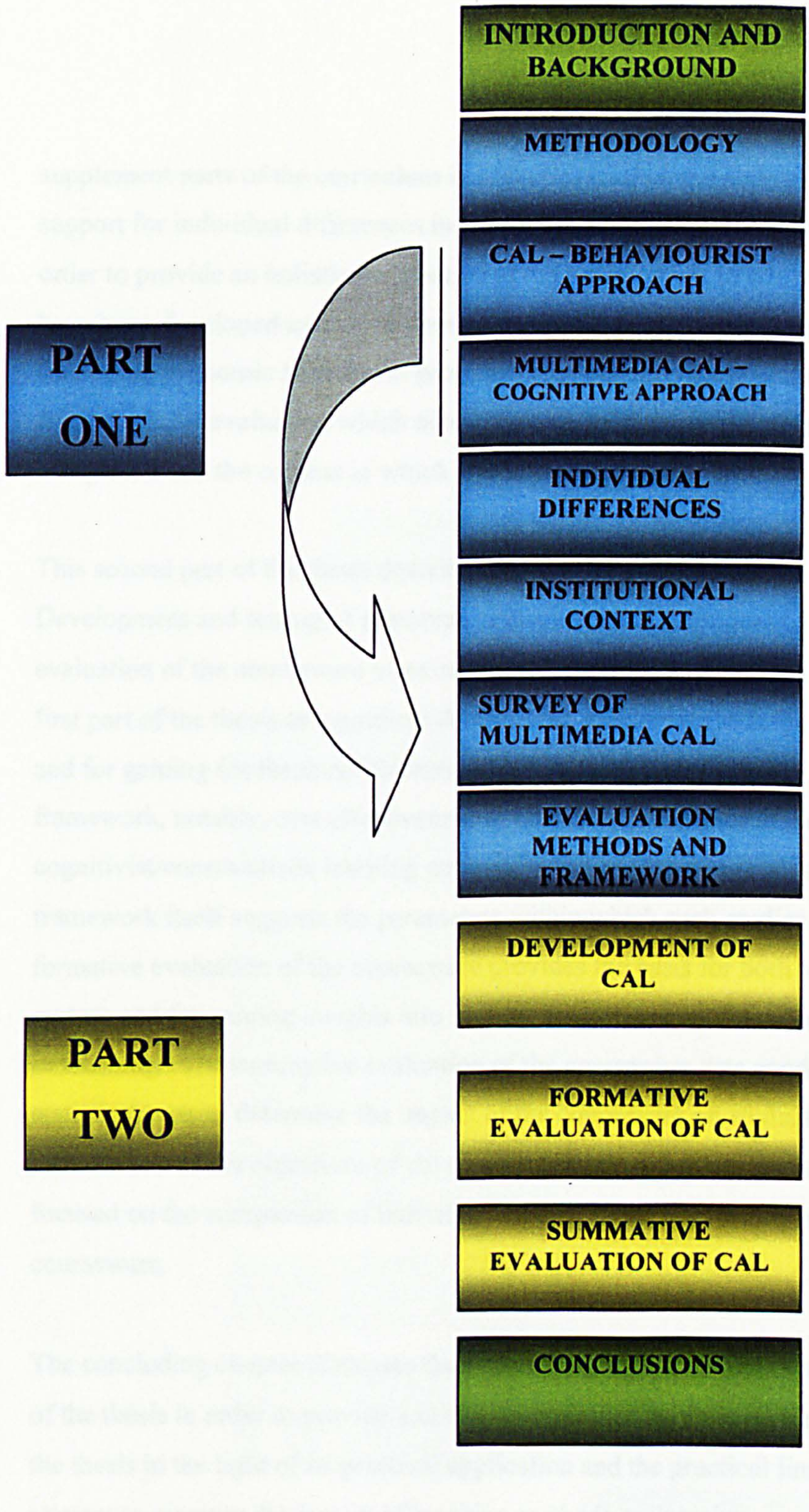

Figure 1.1 Sequential view of structure of thesis

effective learning are the most significant. Linked in particular to claims for CAL as an effective support for a cognitivist approach to learning, an examination of the literature of how CAL can support a variety of learners by catering for individual differences is then provided. It is contended that, in cases where multimedia CAL systems are intended to replace rather than supplement parts of the curriculum in higher education, the ability of such systems to provide support for individual differences in learners is a critical factor in their evaluation. In addition, in order to provide an holistic perspective of the environment in which multimedia CAL systems have been developed and implemented, an examination of broader institutional objectives (including economic benefits) is provided. Collectively, these chapters provide the basis for a framework for evaluation which takes into account the specific objectives of the CAL courseware being used and the context in which it is implemented.

This second part of the thesis describes the development and use of multimedia CAL courseware. Development and testing of prototype courseware and subsequent formative and summative evaluation of the courseware were conducted using the evaluation framework developed in the first part of the thesis as a guide in determining appropriate strategies for testing the courseware and for gaining feedback on students' perceptions of their learning. Some parts of the evaluation framework, notably, cost effectiveness or cost benefit analyses and development and testing of cognitivist/constructivist learning environments, are not explored in the empirical study but the framework itself suggests the parameters within which such studies should be conducted. The formative evaluation of the courseware provides the basis for both testing the usability of the system and for gaining insights into student perceptions on the value of multimedia CAL systems in teaching. The summative evaluation of the courseware was conducted by using a variety of statistical tests to determine the impact of the courseware on student learning. In particular, because one of the objectives of the courseware was to replace parts of the curriculum, these tests focused on the comparison of individual learner differences with performance in using the courseware.

The concluding chapter discusses the issue of evaluation of CAL systems drawing on both parts of the thesis in order to provide a critical appraisal of the framework developed in the first part of the thesis in the light of its practical application and the practical limitations which beset any attempt to measure the impact of teaching methods on learning.

Figure 1.2 below illustrates the main links which integrate the development of the evaluation framework in Part One of the thesis and the empirical study described in Part Two. In particular the diagram highlights the manner in which the claims for the efficacy of multimedia CAL which are based on features of the user interface and opportunity for user control through ability to select non-sequential paths through learning material are tested during the development and formative evaluation of the courseware developed as part of the research.

In addition the diagram highlights the manner in which the important features which are associated in the literature with the ability of CAL to cater for individual learner differences are tested during the summative evaluation of the courseware developed as part of the research.

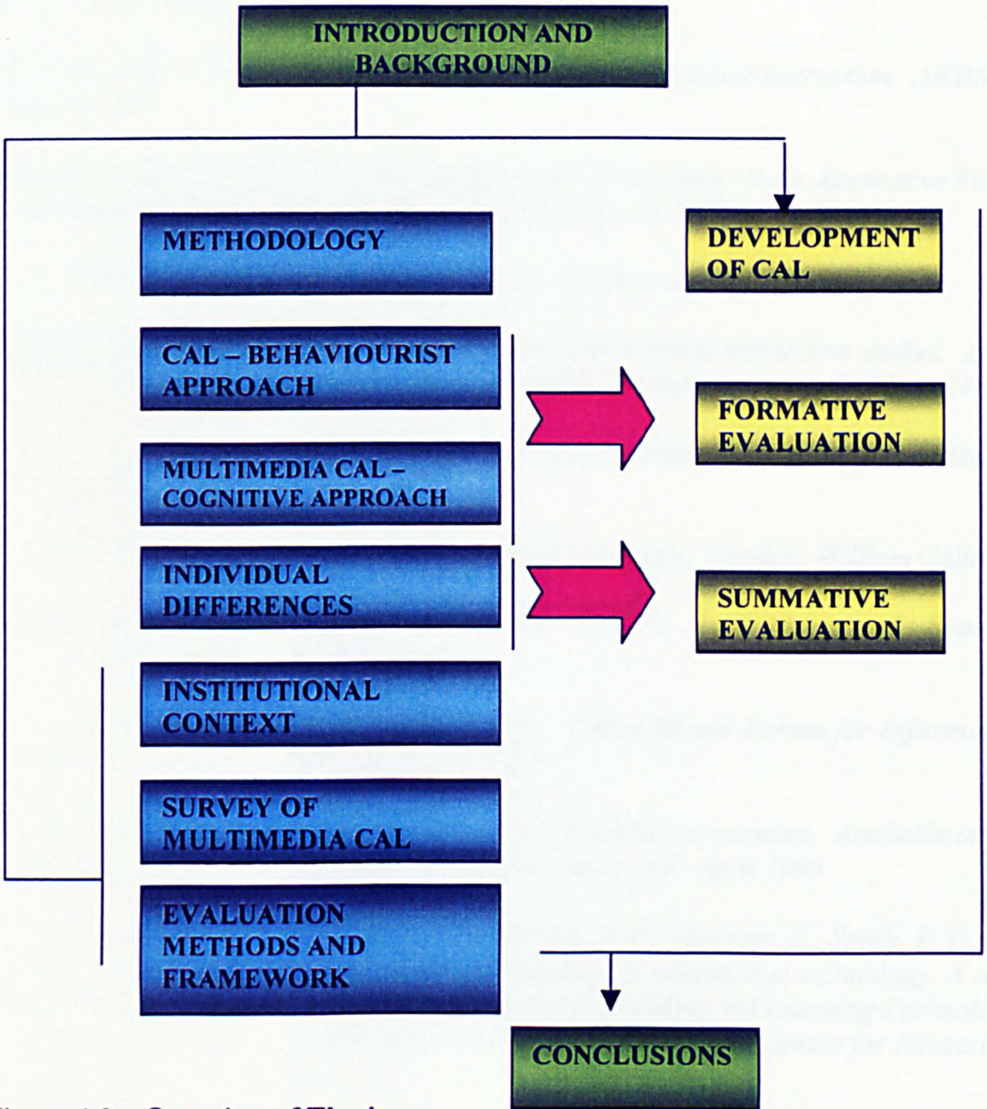

Figure 1.2 – Overview of Thesis showing links

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Chapter Two

Methodology – Literature Review and Development of Evaluation Framework

> *'What sets us against each other is not our aims – they come to the same thing – but our methods, which are the fruit of our varied reasoning.'*
>
> ***(Saint-Exupéry, Wind Sand and Stars)***

2.0 Overview of Methodology

The research involved two main strands:

- literature based and survey work to determine a framework for evaluation of CAL systems and
- a series of empirical studies which revolved around the development and use of a demonstrator courseware package which was used as a tool for exploring student use and attitudes to CAL and to test the proposed framework for evaluation.

Whilst both strands of the research were interwoven (both conceptually and chronologically), the research has, for clarity, been presented in two parts. The methodology for the first part of the research, involving a critical review of the literature and a survey of CAL packages and CAL producers, is presented in this chapter. The aim of this strand was to determine the 'critical success factors' for development of multimedia CAL and hence derive a framework that could be applied to the evaluation of such packages.

The second part of the research was concerned with an examination of the manner in which students use such systems and in particular aimed to investigate the question of how individual learner differences affect student perception and performance using CAL materials. The methodology for the development of the CAL courseware as part of the research is reported in Chapter 9 and empirical tests conducted when formatively and summatively evaluating student use of the courseware are described in Chapters 10 and 11.

It is the methodology for the first part of the research that is discussed in this chapter.

2.1 Literature search and analysis

The starting point for surveying any field of research is to conduct an evaluative study of the literature. This is complicated in the case of research into computer assisted learning by two factors: firstly, the wide range of topics which are encompassed in the literature under the general heading of computer assisted learning (or, as discussed in the previous chapter the various synonymous phrases and acronyms which have been used to describe the concept) and secondly the wide range of themes which are important in developing an holistic approach to determining the pedagogical and practical benefits of using CAL systems in higher education (which forms the basis for evaluating whether such systems are achieving their stated objectives). Thus it was important to examine literature which dealt with learning theory and instructional design. It was also important to examine the specific claims made concerning the mechanisms by which multimedia CAL courseware can support the delivery of 'rich learning environments' linked to specific theories of learning. This involved an analysis of the literature related to hypertext and hypermedia and, in particular, the claims that systems based on these approaches provide enhanced interactivity and thus support for 'learner control'. The research was specifically concerned with the evaluation of CAL systems to support higher education and it was thus also important to examine contextual issues and frameworks which have been proposed for teaching and learning at this level. Finally, it was obviously important to examine previous evaluation studies and to review existing frameworks and models for performing evaluation of CAL.

To provide purpose and direction to the literature search and ensure retrieval of relevant material a range of issues arising out of the research problem were identified and from those the following questions were derived:

- *what is the pedagogical basis for claims which are being made for using computer assisted learning in general and more specifically what are the pedagogical benefits which are claimed for packages which are designed using multimedia/hypermedia interfaces?*
- *what evidence is being presented in the literature to support claims for learning gains, efficiency gains or effectiveness gains resultant from implementing computer assisted learning?*
- *what are the main influences in higher education which are shaping the drive towards developing and using computer assisted learning and what are the political and institutional criteria for evaluating success?*
- *how has the evaluation of computer assisted learning been undertaken with respect to frameworks for teaching and learning in higher education which have been emerging in the 1990s?*
- *what are the current methodologies which have been proposed for evaluating computer assisted learning interventions in higher education and how well do these methodologies provide an accurate measurement of the benefits which have been claimed for these interventions?*

2.1.1 Methodology employed in literature search

Literature was identified by keyword searching of DIALOG and other online hosts. The main databases for useful articles were found to be ERIC (the Educational Resources Information Centre) and BEI (the British Education Index).

The main difficulty encountered when searching databases for relevant literature was the variety of search terms that were potentially relevant. As has been noted in the introductory chapter the terminology used to describe computer assisted learning is diverse. Thus to conduct an exhaustive search required a large number of complex search strategies to be devised and used. The approach adopted was to retrieve as many references as possible within a broad range of subjects (i.e. to maximise the recall of material using different search strategies) and to sift manually through the material to gauge relevance. The key themes around which searches were conducted were: - design and implementation of CAL packages; educational benefits of new learning technologies; the contribution of theories derived from educational psychology to the design of new instructional media; the application of hypertext and hypermedia systems to learning; practical initiatives and theoretical frameworks related to teaching and learning in higher education; and the influence of individual learner characteristics on learning when using CAL. These were all developed in order to provide a robust body of evidence upon which to base the critical review of CAL evaluation. The aim was to derive an holistic model of evaluation which is firmly rooted in the claims made relating to the educational benefits of such systems and is consistent with the overall context of the aims and objectives of higher education.

The literature search was not restricted to application of CAL in a particular subject area. However, because the topic for development of the experimental multimedia package (described in the second part of the thesis) was in the field of information and library studies, an exhaustive search of the relevant database in that subject field (LISA - Library Information Science Abstracts) was conducted. This, however, provided no useful references. Hypertext and hypermedia have been used in information and library services for the provision of basic training on 'how to use the library' or 'how to use the catalogue' or to develop basic information skills. However, there was no research or development on the application of hypertext or hypermedia to the delivery of the curriculum in Information and Library Studies Departments.

Initially it was envisaged that the literature review should be restricted to recent material (published on or after 1990). It was considered that in a technological field the pace of change would be rapid enough to warrant this restriction. However, given the large number of references made to work which had been conducted prior to 1990, the importance of such work to a range of meta-analyses published in the 1990s (Kulik, 1994; Kulik and Kulik, 1991, Khalili and

Shashanni, 1994; Fletcher-Flinn and Gravatt; 1995) and the often uncritical attitude of more recent literature to previous research, it was decided that a chronologically wider range of publications should be studied. It also became obvious as the research progressed that many of the claims for the effectiveness for CAL were based on educational models and theories which have evolved over the course of the last few decades. It was therefore necessary to examine in some detail these theories of teaching and learning in order to comprehend better the pedagogic basis which underpins the context in which the new media were being applied.

The search did identify major projects and initiatives. The most important of these were associated with developments arising from the TLTP programmes (Teaching and Learning with Technology Programme). The most significant TLTP programme for the research was the TILT (Teaching with Independent Learning Technologies) project based at Glasgow University. This project was particularly concerned with the development of instruments for evaluation of the implementation of technology in higher education and some of the evaluation instruments which they had devised were adapted and used in the research presented here. Publications from various CTI (Computers in Teaching Initiative) centres and publications arising from ITTI (Information Technology Training Initiative) projects also proved to be useful. The *CTISS file (from1994 re-titled Active Learning)* was the source of a large number of articles which, though not generally scholarly or academic in their treatment of issues, provided a good source for maintaining awareness of practical projects. More extensive discussion of issues related to evaluation and implementation of CAL generally were found in the *Journal of Educational Multimedia and Hypermedia*, the *Journal of Computer Assisted Learning* and in *Computers in Education*. . These were generally less useful for papers discussing issues related to educational psychology and the *British Journal of Education Technology, the British Journal of Educational Psychology* and *Educational Technology, Research and Development* supplemented this aspect of the literature review.

Academic conferences are often a good source of information, not only in terms of papers which are presented but also in providing the opportunity to discuss key issues with theorists and practitioners. In this respect the ED-MEDIA World Conference on Educational Multimedia, Hypermedia and Telecommunications was identified as the most important conference in the field in which this research was being undertaken. Attendance at these conferences between 1994 and

1999 also provided a useful insight into the way in which the research community's priorities with regard to computer assisted learning were changing and developing.

The literature review also identified individuals who were prominent in research in the field. There are of course a number of academics who publish extensively in the field of instructional design but only a few of these individuals are concerned primarily with issues related to evaluation. The main authority in this area is Professor Thomas C. Reeves of the University of Georgia in the United States and his presentations and writing had a formative influence on the direction of the research presented here (Reeves, 1992a; 1992b; 1993; 1997; 1999). The other major author whose views have been very influential in shaping the direction for this research is Professor Diana Laurillard, currently pro-Vice Chancellor of the Open University in the United Kingdom. Laurillard's work '*Rethinking University Teaching: a framework for the effective use of educational technology*' is widely cited by others working in the higher education sector and is particularly important in expounding the context and objectives of teaching in higher education. (Laurillard, 1993). The model she provides for teaching and learning is a tool that can be used to define more rigorously the scope of computer assisted learning and for defining the parameters which should be used when evaluating educational interventions in general. Using Social Sciences Citation Index, citation searches were conducted for works citing these authors and this provided a very rich source of references.

During the course of the research the Internet became an increasingly important tool for identification of literature and for direct communication with other researchers. Again it was found that, because of the large number of search terms associated with the field of the research, it was difficult to conduct very specific searches for information. Generally, it was found, the best approach to using the Internet was to search associatively using a few key references and authors. (This indeed, is the search methodology for which the WWW is ideally structured. Currently search engines are still not advanced enough to deliver precise and relevant information using natural language or keyword based approaches.) It was possible to use this approach to gather together quickly a large corpus of useful materials. It should be noted, however, that the web as an information resource had to be used with considerable caution. The material provided on the web is of variable quality. However, increasingly it is becoming a vehicle for authors who wish to publish research findings quickly. By carefully examining the authorship of web based publications and comparing this with the author's print based publication it was possible to gain a fairly reliable guide to the academic credibility of web based articles and reviews. The web also offered certain advantages, principally that web authors could often be quickly and easily contacted in order to resolve or clarify issues related to the research that they were describing and also provided access to e-mail discussion lists and bulletin boards hosted by organisations concerned with educational technology.

2.2 Survey of multimedia CAL systems

It might have been expected that in publications which relate to the development of multimedia CAL systems it would be obvious what pedagogic claims were being made for particular packages and this would inform the discussion of the evaluation conducted to determine the success of the software packages. This however, proved not to be the case. During the analysis of the literature it became apparent very quickly that, whilst there is an abundance of literature which reports on research in use of computer assisted learning, only a small fraction of the literature develops the theme of evaluation of the use of CAL. Within this body of literature the research to date has concentrated very heavily on the formative evaluation of instructional materials and the description of the developmental processes and technology for creating CAL software. There is a much smaller corpus of literature that examines themes such as :

- *performance gains by students and the extent to which this can be explained as being attributable to use of CAL systems;*
- *the way in which individual learner differences influence student approaches to learning using CAL and influence individual evaluation of courseware;*
- *the implementation of CAL systems in 'real life' settings as opposed to experimental studies.*

Concerns such as those listed above and other issues related to evaluation are dealt with in a very peripheral manner and are often provided as minor appendages to papers and reports that are more concerned with a description of how the technology has been used. Thus, a review of the literature based evidence was complicated by the fact that much of the literature does not provide enough detail on the methodological steps taken in evaluation of CAL to make it easy to replicate or validate findings. As noted above, some meta-analyses were identified which attempted to summarise findings from a range of studies. However, concerns over parts of the methodology employed in meta-analyses and thus the conclusions they derive from the evidence presented (Clark and Snow, 1975; Driscoll, 1995; Ehrmann, 1995; Reeves, 1999) made this line of investigation using the literature problematic. The literature search itself clearly demonstrated that there is a distinct difference of approach evident between work which has been undertaken on the development of CAL systems and research which is being conducted on how such systems should ideally be evaluated. Despite the fact that most developers acknowledge the importance of the latter it rarely receives prominence in the reporting of findings and there appears to be a gap between the literature that advocates use of particular evaluation techniques and the implementation of such techniques in practice. As Gunn notes there are a number of cases where:

> *evaluation is 'tacked on' to the end of a project 'as a token summative measure or even excluded entirely for being too difficult or expensive to handle (Gunn, 1996, p.157)*

Furthermore where evaluation is described in the literature, details on the aims and objectives of many CAL packages are poorly described and thus it is difficult to gauge the appropriateness of the evaluation procedures which have been adopted.

A fundamental problem that was identified at an early stage of the research was that the evaluation of CAL was complex because of the diverse nature of approaches taken to the design and development of CAL packages. It appeared likely that different types of evaluation would be required depending on the purpose for which CAL packages were being designed and in particular the pedagogic approaches which they claimed to support. Sufficient detail on the range and appropriateness of evaluation techniques could not be provided purely from an examination of descriptions and evaluations of the packages as presented in the literature. Thus, during the course of the research a large number of CAL packages were critically reviewed in order to gain a better understanding of the various uses for which CAL materials were being developed and the characteristics which they exhibited which could support their claims for particular pedagogic benefits. This formed the basis of developing a broad taxonomy of CAL systems based on the manner in which systems support learning and in particular based on the pedagogic theories that underpinned their development.

It is important to define clearly the methodology by which this review was conducted and in particular clearly distinguish the methodology from that used in conventional case studies. A case study is designed specifically to provide a description of all the complexities of a particular case. As Stakes notes "Case study is the study of particularity and complexity of a single case, coming to understand its activity within important circumstances'. (Stakes, 1995). The rationale for case study research adopted with respect to CAL implementations is provided by Hewer, who comments that 'the questions most often asked by academics contemplating implementing the use of learning technology are 'Does it work?' and 'How do you do it?'" (Hewer, 1997). She goes on to assert that the evidence from case studies of successful implementations helps to answer these questions.(Hewer, 1997). A number of authors have provided evidence developed from case studies to attempt to demonstrate the mechanics by which particular packages achieve their objectives (e.g. Milne and Heath, 1997). In addition to the eight case studies provided by Hewer, published studies by the TLTP (Teaching and Learning with Technology Programme), TLTSN (Teaching and Learning with Technology Support Network) and others have provided further insights into practical application of CAL packages. However, whilst such studies have the potential to provide useful data on particular applications of computer assisted learning they fail to provide a clear body of evidence which allows generalisation from the case being investigated to the broader issues concerning evaluation. In terms of Stake's categorisation of case studies a common feature of CAL case studies is that they are *intrinsic case studies* (in which the objective is to learn more about the particular case) rather than *instrumental case studies* (in which the case study is instrumental in providing a clearer understanding of more general issues).

The objective of the practical review of CAL systems conducted as part of this research was to develop a taxonomy of CAL applications based on the approach taken in their development in order to gain a clearer understanding of the basis on which such systems should be evaluated. This was important to ensure that the framework being developed for evaluation was broad enough to incorporate all types of courseware. Because of the wide range of CAL applications and a wide geographic spread of applications development work it was concluded that detailed individual case study research of CAL systems evaluation was not appropriate. There are a number of features of CAL that could potentially be examined to provide the basis for classification of CAL systems. Reeves has attempted to quantify some of these in his work on the effective dimensions of interactive learning systems. (Reeves, 1994). The approach adopted to practical examination of CAL implementations was to perform a remote investigation of the systems themselves and to use the discussion on the pedagogic basis for CAL (developed in Chapters Three and Four) to categorise the systems according to pedagogic approach – effectively concentrating on the first three of Reeve's pedagogical dimensions. (See Appendix 1)

It was envisaged that it would be possible to select a range of systems which had previously been identified in the literature and which appeared to offer an interesting perspective or novel approach in the use of CAL in higher education. However, a complication which severely restricted choice was that, whilst descriptions of CAL packages in the literature often appear to imply that such systems are fully functional and in general use, it was often the case that when approached directly the response of system developers was that the system was still at 'an experimental stage' or was not yet fully implemented, or in some cases that the package was no longer available, having simply been designed for test purposes. Systems were thus selected for review largely on the basis of pragmatic criteria. Attendance at conferences and exhibitions at which CAL systems were being demonstrated meant that a number of systems could be reviewed. In some cases fully working demonstrations of systems could be acquired for closer inspection. Also a number of systems were available over the Internet or could easily be downloaded from the Internet. In some cases, it was easy to identify (though not necessarily to obtain) CAL courseware because the products were outputs from the publicly funded TLTP programmes [1] and in three cases CAL packages that were already being used within the Robert Gordon University were investigated. A total of 48 packages were surveyed.

2.3 Questionnaires Survey of CAL producers

Finally, in order to provide a perspective of the rationale for developing courseware using a particular pedagogic approach from the viewpoint of the developers of CAL systems a

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1 *In fact TLTP products proved a less fruitful source of material than had been originally envisaged. It was assumed that, given the large body of CAL material being produced, systems could be selected readily easily. The TLTP web catalogues a large number of packages in a range of subject areas. (TLTP, 1996). However, although in theory access to TLTP CAL packages was not a problem there were practical difficulties in obtaining material and this restricted the choice of systems to be investigated. Mogey provides a useful discussion of some of the problems involved in gaining access to TLTP software. (Mogey, 1996).*

questionnaire survey of producers of CAL software was planned and executed. In order to conduct this as efficiently as possible the initial questionnaire survey was conducted electronically. An e-mail survey of 58 developers (mainly again those who had been active in producing software for TLTP programmes) was undertaken. The main objective of the questionnaire was to gain information on how the developers evaluated their software and to examine the perceptions of courseware producers of the value and potential of the materials which they had developed. CAL developers were asked to comment on the specific aims and objectives which they set themselves when developing the courseware, the general approach taken to design, novel features which were implemented and the mechanisms they employed to evaluate the results of their development work and the extent to which the courseware was currently being used. (The full questionnaire is presented in Appendix 2)

The response rate to this survey was very poor (21% i.e. 12 responses). Although useful data was provided by those who participated it was found that in many cases those members of staff who had been responsible for designing and implementing CAL packages were no longer involved in the project. In order to gain further responses a series of telephone interviews targeted at developers of CAL software was conducted. This was based on the questionnaire and elicited a further 7 responses.

The questionnaire and telephone responses were analysed to identify recurrent themes which were of concern to developers and also to identify instances where theory and practice converged and diverged (particularly in relation to the formulation and support of educational aims and objectives). Because of the small size of the sample, powerful tools for analysis of the responses (such as use of NUD-IST software) were not felt to be appropriate. The methodology used to analyse the responses was based on McKernan's work on content analysis. McKernan's procedures are based on an examination of the 'communication' to derive potential classification categories, writing definitions of these key categories, analysing the data and coding it and finally providing a quantitative summary of the categories to highlight the relative importance of different themes. (McKernan, 1996).

2.4 Conclusion

By conducting this programme of literature review and practical investigation of CAL systems a very detailed picture emerged which encompassed both the theory and practice of developing multimedia CAL systems in higher education and this was an essential part of being able to develop a framework for evaluating such systems. There is a strong body of opinion which affirms the importance of the development of sound pedagogical objectives in CAL materials and also advocates a very rigorous approach to evaluation. However, the practical manner in which such an evaluation should be conducted and the specific detail of how evaluation should be conducted in the context of the aims and objectives of individual courseware packages is often left unresolved. The methodology adopted in this part of the research sought to examine both the potential for multimedia CAL to support sound pedagogical theories and also sought to demonstrate how the impact of such theories can be evaluated in practice for different types of courseware. This was designed to provide the basis for the development of robust conclusions relating to recommended procedures for evaluating CAL materials with respect to objective criteria related to their design and intended use.

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Chapter Three

Computer Assisted Learning – Behaviourist Approaches

> *'In their distress the wisest [teachers] are tempted to adopt violent means, to proclaim martial law, corporal punishment, mechanical arrangements, bribes, spies, wrath, main strength and ignorance, in place of that wise and genial providential influence that they had hoped, and yet hope in some future date to adopt.'*
>
> ***(Emerson, R.W. Essay on Education)***

3.0 Objectives

The objectives of this chapter are:

- to examine the historical context in which computer assisted learning has developed

and

- to discuss the pedagogical goals for the behaviourist model of learning on which many of the early experiments in the use of computer assisted learning were based. This discussion will focus in particular on the limitations on the educational objectives which such a model can support
- to determine factors which are important in a model of CAL environments which is based on behaviourist principles

3.1 Computer Assisted Learning

The term computer assisted learning is used to encompass a broad range of educational software. Taylor was probably the first author in the field to attempt to make some sort of classification of the different uses of the computer. He used the categories: tool, tutor and tutee to classify instructional technology (Taylor, 1980). This taxonomy has been retained in current works on computers in education.

Use of the computer as a tool covers the use of a range of applications software, e.g. word-processing, spreadsheets and learning in order to assist academic productivity – both by the students and by staff. This is not really central to the theme of this research and is therefore not considered here in detail. It is worth noting, however, that there is some confusion in the literature between the application of IT generally and the use of computers as a medium for delivering teaching. This is particularly true in works that are concerned with the procedural issues relating to introduction of new technology into universities. The underlying confusion arises often out of the assumption that because CAL involves students in making use of new technology that students and teachers must have well developed skills in the application of computers in a range of standard software packages. When using modern CAL packages a high level of computer literacy is not a pre-requisite. It is true, however, to say that there is often a perception, on the part of both teachers and students, that the delivery of parts of the curriculum using CAL pre-supposes that those with a 'technical' or 'scientific' background will be more receptive to using the technology and will benefit more when using it. Some of these pre-suppositions are explored in the second part of the thesis which examines the development and practical implementation of a CAL package.

Use of computers as a tutee refers to activities such as programming or engaging in the process of creating or authoring multimedia packages. It is argued by some that these activities encourage students to learn. Taylor argued that

> *Neither the tutor nor tool mode confers upon the user much of the general educational benefit associated with the computer in its third mode, as tutee (Taylor, 1980, p.10).*

The most influential advocate of this approach has been Seymour Papert who at MIT was one of the founders of the artificial intelligence movement. Through his work with Piaget and interest in children's learning he became involved with the development of LOGO and was one of the earliest advocates of a constructivist view of learning as opposed to what was seen as a rigid authoritarian model for transmitting learning. Papert argued that:

> *Children can learn to use computers in a masterful way and ... learning to use computers can change the way they learn everything else. (Papert, 1980).*

Constructivism as an important and influential pedagogic approach to developing CAL systems will be discussed fully in Chapter Four.

The use of the computer as a tool to construct learning is evident in very advanced developments in CAL systems. It is in terms of using the computer as tutor that the main focus of the discussion is presented here. More specifically the discussion centres around the creation of multimedia 'courseware' which is designed to supplement or replace traditional classroom instruction based on the design and construction of learning environments by individuals or teams of courseware developers. It does not deal with the field of intelligent tutoring systems which seek to replicate in computer software the expertise of a human teacher. The aim of intelligent tutoring systems is to generate content and interactions which adapt to individual learners' needs.(Sleeman and Brown, 1982; Kearsley, 1987; Polson and Richardson, 1988) Although the fields of artificial intelligence and intelligent tutoring have often been closely allied to the development of computer assisted learning and instructional design, the ultimate objectives and the tools used to achieve these objectives in the two fields have been quite distinct. The central conceptual problems involved in intelligent tutoring systems focus on teaching strategies rather than learning. Hartley, arguing for closer collaboration between practitioners in both fields noted in his guest editorial in the Journal of Computer Assisted Learning in 1998 that:

> *'Computer Assisted Learning (CAL) practices and Artificial Intelligence (AI) prototypes have always remained at a distance with few successful attempts to establish dialogues between the respective researchers and developers' (Hartley, 1998, Editorial)*

However, Boyle in his discussion of multimedia learning systems is more critical and argues against intelligent tutoring systems both on a theoretical and a technical level stating that:

> *"It may be argued that we need to start with learning and delineate the role of instruction rather than start with instruction and delineate the role of learning ... and ... at a technical level the ITS [Intelligent Tutoring Systems] approach represents an immensely complex approach to building learning environments. IMLE (Interactive Multimedia Learning Envirnoments) development has been greatly enriched by contributions from a wide range of disciplines. To provide systems that only expert cognitive scientists could build would seem to be a step backwards." (Boyle, 1997, p.48).*

On balance an examination of the literature related to ITS confirms Boyle's view of what current development in the field rather than Hartley's optimism for prospective developments. Thus the thesis will examine the design and use of systems which rely on reproduction of teaching methods and materials using the computer as a delivery platform rather than as a tool to replicate expert knowledge.

In the context of developing multimedia CAL systems to perform a 'tutoring' function, a further classification which is often used to describe CAL packages is based on the primary means by which the delivery of instruction is conducted. This can range from simple drill and practice packages, largely text based tutorial packages, multimedia systems which employ a combination of text, audio, graphics and video, packages which provide simulations and packages which are developed as learning games. The order in which these various categories within computer assisted learning systems are listed above corresponds with the level of increasing complexity of the systems in terms of design. It also corresponds to a large degree with the type of educational benefits which are to be derived from the different approaches, the more complex applications generally claiming much more ambitious results in the quality of the learning experience which they provide.

Finally, a significant distinction that is evident in discussion in the literature concerns a dichotomy of purpose in pedagogic approach in CAL systems, in particular between those which exhibit or encourage a behaviourist approach to learning and those which take a cognitive approach. With respect to the latter, more recently there has been a trend towards the application of constructivist theories in instructional systems and some extremely interesting work is currently being conducted on developing CAL systems which provide tools and interfaces to support a constructivist learning environment. These three paradigms (behaviourist, cognitive and constructivist) have characterised approaches to instructional design using computers. They are closely associated with parallel paradigms which have dominated educational psychology, namely behavioural psychology, information processing psychology and knowledge construction. In the field of educational psychology or instructional psychology it is possible to distinguish clear boundaries between the development and popularity of different theories of teaching and learning. The dominant educational paradigms can in fact be identified with specific dates. Wilson, for example, suggests that behavioural psychology was dominant between 1960 and 1975, information processing psychology between 1976 and 1988 and that from 1989 till now we have seen theories of knowledge construction and social mediation as being of central importance. (Wilson, 1996). However, it is not easy to see such a clear differentiation in terms of application of these theories in the field of instructional design. To an extent this is explained by the fact that mainstream educational psychologists have concentrated on issues of performance modelling and cognitive task analysis without concerning themselves with the challenge of devising effective instructional models to develop these theories in practice. While Resnick contended that:

> *instructional design theory ..., which is directly concerned with prescribing interventions, has developed without much reference to cognitive psychology (Resnick, 1982, p.693)*

the evidence from more recent literature does not support this assertion. The problem rather has been that the application of such theories has been complicated by a range of environmental and attitudinal factors which have made it difficult to implement theory in practice. In the field of computer assisted learning it has been even more complex because of the additional complication which arises when one considers the technology available for delivery and the limitations of the technology to create the type of environments which are required to mirror theory.

This chapter will introduce the discussion of the benefits of computer assisted learning by examining the way in which instructional technology has developed and will concentrate on the manner in which the behaviourist approach to education can be seen to influence such developments.

3.2 Historical Background

Since the introduction of the computer as a tool in the classroom, the prospect of "automating" teaching has been a major pre-occupation of many educators and educational technologists. The following discussion of the history of CAL is necessarily brief and concentrates only on the major developments in educational CAL. A fuller survey of the development of Computer Assisted Learning since the 1950s is provided by Saettler (Saettler, 1990).

Throughout the 1960s and 1970s there was substantial evidence of growing interest in the potential of computer assisted learning. This was prompted by a number of factors, the first two of which have an uncanny resonance with more recent enthusiasm and support for CAL. Firstly developments in computing technology in the 1960s were making the technology more accessible for non-scientific or technical users. Kinzer, Sherwood, and Bransford (1986) point out the significance of the development of the IBM 1500 computer as "the only computer ever developed specifically for computer-assisted instruction, rather than as a general-purpose computer for widespread applications". The rapid developments in technology which were making it easier to create and present text (and in a more limited fashion graphics) on computer appeared to be sufficient reason for making use of the technology. Secondly, particularly within the United States there was a belief by government, as funders of CAL projects, that CAL ought to be effective.[1] Furthermore this belief extended to a conviction that the technology to deliver instruction by computer would also result in a more cost effective solution for delivering quality education for all.[2] (A belief, which it should be noted appeared to be unshaken despite convincing evidence to the contrary). Thirdly, the potential for CAL development was consonant with instructional design principles which were based very much around extreme behaviourist reduction as characterised by behaviourist psychologists such as B.F. Skinner. The framework of

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[1] *An interesting discussion of this is provided by Ehrmann in his paper 'Looking backward: US efforts to transform undergraduate education' (Martin, 1994) in which he briefly examines the work of the Carnegie Commission, FIPSE (Fund for the Improvement of Post Secondary Education, and more recently the Annenberg/CPB (Corporation for Public Broadcasting) project.*

[2] *A parallel development in the United Kingdom is evident in the major initiatives planned by the Wilson government in the 1960s to enhance the delivery of education to all using the 'white heat of technology'. The significant outcome of this was of course the development of the Open University.*

instructional theory which grew up around behaviourism provided the basis for a 'technical' approach to the delivery of instruction centred on the rigid optimisation of presentation of learning materials. In particular the views of Gagné as propounded in *The conditions of learning* provided a very formal system of design for learning which could be easily adapted for development in a computer based environment.(Gagné, 1985; Kemp, 1985)

Early examples of confidence in the use of technology to deliver learning are most evident in large scale projects such as PLATO (Programmed Logic for Automatic Teaching Operation) at the University of Illinois and TICCIT (Merril, Schneiderman and Fletcher, 1980). These projects are generally credited as illustrative of development of the first systems which provided evidence that the potential benefits of educational computing were substantial and also highlighted some of the important issues which mitigated against such systems fulfilling their potential.

PLATO originated in the early 1960's at the Urbana campus of the University of Illinois. Professor Don Bitzer became interested in using computers for teaching, and with some colleagues founded the Computer-based Education Research Laboratory (CERL). Bitzer, an electrical engineer, collaborated with a few other engineers to design the PLATO hardware. To write the software, he collected together a 'courseware development team' which included both university professors and students, few of whom had any computer background. Together they built a system that was considerably ahead of its time in many ways. (Bitzer, 1976)
PLATO was a timesharing system. (It was, in fact, one of the first timesharing systems to be operated in public.) Both courseware authors and their students used high-resolution graphics display terminals, connected to a central mainframe. A special-purpose programming language (TUTOR) was used to write educational software. Throughout the 1960's, PLATO remained a small system, supporting only a single classroom of terminals but in the 1970s developed and was implemented on a new generation of mainframes allowing the system to support up to one thousand users simultaneously. By the 1980s, however, the widespread adoption of microcomputers (seen as a more cost-effective platform for education than large mainframe systems) and problems with the hardware and software support heralded the demise of PLATO as a publicly funded programme. As an educational/multimedia system, PLATO had many influences. Its most successful direct descendant is TenCORE™, a DOS-based authoring system. Macromedia's Authorware™, an authoring system for the Macintosh and Windows, is also firmly

rooted in PLATO and Lotus Notes™ evolved from the pioneering work done by the PLATO team in developing an online system to allow direct communication between teachers and learners.

TICCIT (Time-Shared Interactive Computer Controlled Information Television) is another major CAL system developed at the University of Texas and Brigham Young University and funded by a grant from the National Science Foundation (NSF) in 1971. TICCIT mathematics and English courses were launched at two community colleges, Phoenix College in Arizona and Northern Virginia in Alexandria in 1971-72. The aim of the project was to demonstrate that computer assisted instruction could "provide today better instruction at less cost than traditional instruction in community colleges" (Mitre Corporation, 1976). This system was designed to teach higher-order concepts using an instructional design system called RULEG. RULEG provided a general statement, or rule, and examples of how the rule is applied. Niemiec and Walberg note that this system was innovative because the "instructional tactics were unique to the system and not particular to the authors of programs" (Niemiec and Walberg,1987;1989). Chambers, who conducted an evaluation of TICCIT notes that:

> *"For the first time, a large scale project emphasised innovative approaches to hardware as well as in-depth consideration of learning theory and instructional strategies in the design of the course materials" (Chambers and Sprecher, 1980, Quoted in Black, 1995 Online).*

The main characteristic of the system in terms of design was a very rigid approach to the development of course material. The 'courseware team' consisted of a subject expert, an instructional design specialist, an educational psychologist, a design expert and an 'evaluation technician' and this mix of skills was common across all of the subject packages which were devised. This was consistent with the project's philosophy that the effectiveness of a learning strategy was independent of subject matter. Like the PLATO software the withdrawal of NSF funding resulted in the commercialisation of the TICCIT software and hardware. It is currently being marketed by the Mitre Corporation.

The productivity of both projects was very impressive but this has to be seen in the context of very substantial resources which were provided by government funding. Ultimately neither project came close to achieving the economic gains which they set out to achieve. Other areas of the evaluation of both systems also give grounds for concern.

At the end of the first five years of the PLATO project, despite collecting a huge volume of data there was no conclusive proof that use of the system had any effect on student learning. Furthermore, whilst students had a generally favourable attitude to the system a significant number were not happy with the use of the computers for instruction (27%) and 88% 'would not want to have a whole course taught on PLATO' (O'Shea, 1983). TICCIT, as noted above, attempted to test the effectiveness of computer assisted learning against the traditional classroom format. Thus the approach in TICCIT was to use computer instruction as a replacement rather than a supplement to course delivery. But the evaluation provided a very mixed response. Both the TICCIT Mathematics and English course students reported "significant achievement" over the traditional classroom formats. However, more students favoured lecture classes over TICCIT mathematics courses, and fewer students completed the TICCIT mathematics courses as compared to the standard (Chambers and Sprecher, 1980). This dichotomy between claimed 'educational benefits' in terms of 'better' learning as defined in test scores and a reported lack of enthusiasm on behalf of participants is common in many early studies into computer assisted learning. The major criticism of the system was the manner in which it had been implemented, which did not take sufficient account of individual learners' needs and the need to engage in a dialogue with students. For the first time computer assisted learning research highlighted the point that there were factors beyond the instruction materials which influenced effectiveness and this was to have a significant impact on the manner in which CAL materials should be assessed. Such considerations, however, were not to have an immediate impact on much of the work which was subsequently conducted on development of CAL applications.

By the 1970s and 1980s there was a substantial increase in the number of applications of computer assisted learning within higher education (though it could not be said to be making a significant impact). (Cody, 1973). However, in tandem with this there was a growing body of opinion which was beginning to question the appropriateness of these applications with reference to the objectives of higher education teaching. (Achilles, 1982; Atkins, 1993; Edwards, 1975; Jamison, 1974). Much of the criticism centred around the reliability of such systems and their inability to provide engaging environments for students. A great many of the packages relied very heavily on text. Graphics, where included, were generally of poor quality and sound was often not featured at all.

It is obvious from many studies which are reported in the literature that unreliable technology was a major demotivating factor and an examination of some of the early attempts to produce instructional software provides a rather depressing impression that enthusiastic amateur programmers were intent on demonstrating their skills at constructing poor software rather than being engaged in a serious attempt to produce sound educational materials. (Bork, 1984) Given the very limited computing resources available in terms of processing power and storage, it is easy in retrospect to see why such attempts were not successful. The literature is full of references to problems which relate to not having enough hardware resources for teaching large classes, staff training in use of hardware being inadequate, lack of technical support and standards and problems of general levels of computer literacy. (Clement, 1981; Cohen, 1983; Holmes, 1983). The real heart of the problem however lies with the lack of an overall rationale and strategy for introducing technology into teaching.

3.3 Pedagogical Basis for Computer Assisted Learning

The first attempts to use computers in education were based on behaviourist theories with emphasis on feedback and reinforcement actions (Burney, 1996; Ertmer and Newby, 1993). Associationist philosophers (such as Aristotle, Hobbes and Hume) laid the foundations of behaviorism. Hume's work on associations and antecedents, the work of Brown and Ebbinghaus on 'recency' and vividness of association and Bain's links between association and sensory stimuli were all influential in developing a theoretical model for a behaviourist approach in educational psychology. (Black, 1995). Generally, however, most commentators concur that the most significant influential factor in the development of the behaviourist approach was Pavlov's studies on conditioned reflexes and conditioned stimuli during his famous studies on the salivary responses of dogs. These experiments, conducted at the start of the twentieth century, marked the beginnings of the behaviourist movement in psychology. Watson clearly stated the position of behaviourism in psychology stating that:

> *'Psychology as the behaviorist views it is a purely objective experimental branch of natural science. Its theoretical goal is the prediction and control of behavior. Introspection forms no essential part of its methods'. (Watson, 1919)*

Behavioural psychology applied to education revolves around the premise that learning results from the pairing of responses with stimuli. The approach as applied to educational theory is most commonly associated with Thorndike's theories on connectionism (Thorndike, 1912, 1913,1932) and Skinner's theory of operant condition. (Skinner, 1969). Connectionism was originally propounded as a general theory of learning for animals and humans and is based upon the idea that learning is a function of change in overt behavior.

> *A good simple definition or description of a man's mind is that it is his connection system, adapting the responses of thought, feeling and action that he makes to the situation that he meets. (Thorndike, 1943 quoted by Black, 1995 Online).*

Changes in behavior are the result of an individual's response to events (stimuli) that occur in the environment. Skinner emphasized the point that when a particular Stimulus-Response (S-R) pattern is reinforced (rewarded), the individual is conditioned to respond. This was a theme picked up by other educational theorists. Thus Guthrie, for example, in putting forward his 'contiguity theory' argued that all learning was a consequence of association between a particular stimulus and response (Guthrie, 1930). Central to the general behaviorist model is the concept of reinforcement. Reinforcement follows the response and it is argued that positive reinforcement to a correct response should be provided and negative reinforcement should always be provided for a wrong response. A reinforcer is anything that strengthens the desired response. It could be verbal praise, a good grade or a feeling of increased accomplishment or satisfaction. Negative reinforcers (e.g. punishment) result in the reduction of undesired responses. A great deal of attention was given by Skinner to developing schedules of reinforcement and examining their effects on establishing and maintaining behavior.

These reinforcers it was argued will encourage learners to respond appropriately. The paradigm for stimulus-response theory was trial and error learning in which certain responses come to dominate others due to rewards. The hallmark of connectionism and operant conditioning (like all behavioral theory) was that learning could be adequately explained without referring to any unobservable internal states. For learning to take place the behaviour (or response of the learner) simply has to be modified or shaped by reinforcing it appropriately. Essentially we could implement a behaviour change programme (or teaching programme) by observing the following five steps:

1. Set behaviour goals
2. Determine re-inforcers
3. Select procedures to change behaviour
4. Implement procedures
5. Evaluate progress and revise as necessary

As a consequence, there are several principles (Thorndike terms these Laws) which have been derived from behavioural learning theory which it was commonly argued needed to be incorporated into instructional design generally and by inference in computer assisted learning programme design:

- The response to the learner must follow on immediately from the stimulus to which the learner is invited to respond (Principle of contiguity (Gagné and Briggs (1979)). It is argued that if longer periods of time elapse between the stimulus and response then the probability that the learner will correctly associate (or pair) the stimulus and response will be diminished. (Thornburg, 1984; Houston, 1976);

- Practice is essential in order to strengthen the association between stimulus and response. (Principle of Repetition). Thus repetition of stimulus/response will encourage the imprinting of the pattern on the learner and result in more 'effective learning'. (Loree, 1965; Houston; 1976);

- Feedback is desirable, particularly for incorrect responses in order to reduce the likelihood of repeated error. (Loree, 1965) Consistent repetition of an incorrect response is an indication that learning has not taken place and this must be eliminated by repeated feedback. (Principle of Reinforcement). Thus the learner must be given information which not only indicates a correct or incorrect response but also be given further guidance on the appropriateness of the response given. (Kolesnik, 1976; Houston, 1976)

In addition to those guiding principles various authors (Thornburg, 1984, Houston, 1976) have suggested that the student should be provided with support in order to arrive at the desired response. This support should begin very overtly with cues to guide the learner to the correct response and gradually such cues are removed and the learner should be able to arrive at the correct response independently. As Hannafin notes:

> *The terms* prompting *and* fading *refer to the process of providing several or alternate stimuli to shape the desired response. Eventually the learner progresses from the point at which the desired response is provided under cued conditions to the point at which the response is elicited under the desired conditions'. (Hannafin and Peck, 1988, p.47).*

This exposes the fundamental weakness of the behaviourist approach in that it is based almost solely in achieving a 'transfer of learning' to the student and the sole manner in which this transfer is assessed or evaluated is that the student should be able to reproduce accurately the material with which he/she has been presented. This model of learning emphasises the systematic presentation of information and at its most extreme denies any individual differences in the learner. It is restricted to external observable behaviour and does not attempt to take into account any factors which might explain why a particular pattern of behaviour occurs.

Thus education is reduced to a "one way flow" of information and the process of education is essentially seen as a process of providing knowledge to the student - the student being reduced to a passive recipient of this commodity. This approach is vividly described by Davies as the "Hydraulic Theory of Education" from which O'Shea quotes as follows:

> *"There is an educational theory prevalent that might be called the Hydraulic Theory. It is a practical rather than a formal theory in that its disciples do not advocate the theory in any formal way: they merely act as though they believe it. Nevertheless, the Hydraulic Theory is respectable, its practitioners many, its tradition long, and its influence dominant. According to the Hydraulic Theory, knowledge is a kind of liquid which resides copiously in teachers and books, as in greater vessels, and hardly at all anywhere else. Particularly it is scarce in the smaller vessels known as students. The purpose of education, then, is to transfer this liquid from the larger to the smaller vessels." (Davies, 1969; quoted in O'Shea, 1983, p67.)*

Whilst it is rare now to find the approach being advocated formally, the substance of this approach can still be seen to underpin much of our traditional methods for delivering the curriculum. A characteristic of this approach is that the learner assumes a passive role and thus the type of learning which results is what has been termed "surface" i.e. it consists largely of remembering facts or events, accepting ideas or information and does not encourage reflection on what is being given.

The computer assisted learning packages conforming to this educational theory in its most basic form have thus been characterised and criticised because:

- the teaching path was fixed and linear;
- the communication style was monodirectional (from the computer to the student) and imperative;
- individuality was restricted to the amount of time spent in the learning process.

In his classic 1954 article, *The Science of Learning and the Art of Teaching*, Skinner described the conditions of the typical classroom as particularly adverse to learning (Skinner, 1954). A single teacher cannot individually and appropriately reinforce thirty or more students at the same time. In this article Skinner first conceptualized a teaching machine for the classroom for use by individual students. This machine could present information, reinforce appropriately and then branch to the next level of difficulty depending on the individual's performance. The roots of computer-assisted instruction can be easily seen in Skinner's teaching machine. In addition the theory of operant conditioning is often directly linked to the development of programmed instruction and thence as a general framework for developing computer assisted learning. (Markle, 1969). Keller's work on developing the Personalized System of Instruction was very influential in this respect and his linear and branching programming designs for developing programmed learning had a significant impact on the development of 'teaching programmes' throughout the 1970s and 1980s.

Programmed Instruction is characterized by:

- clearly stated behavioral objectives
- small frames of instruction
- self-pacing
- active learner response to inserted questions
- immediate feedback to the correctness of the response

Thus it can be seen that programmed instruction shifted the focus of education to the outcome behaviour of the learner and away from process concerns and teacher behaviour. This general method affirmed the feasibility of self-pacing and mastery learning which was developed by Morrison in the 1930s (Saettler, 1990) and adopting such an approach tended to emphasise the belief that the single most important factor which was central to 'learning' was the development of carefully constructed course materials. This being the case it was logical to assume that given the tools to handle not only text but also other information formats the methods of programmed instruction could be even more effectively applied. Given the ability to produce such systems the stage was set for developing large systems of instruction based around the principles of programmed instruction. Thus programmed instruction and operant conditioning, almost inevitably, became very closely linked to the burgeoning development of computer assisted learning materials.

In the 1980s a synthesis of previous theories and a direct link to their application using technology can be seen in the work of a number of writers who have produced theories based upon a model of learning which although rooted in behaviourism are also derived from information processing theory. The most notable and influential of these was Gagné. (Gagné and Briggs, 1979; Gagne, 1985). Whilst Gagné's work was initially very much focussed on achieving certain observable outputs from the learning process (a hallmark of behavioural theory) later developments of his theory seek to explain the learning process in terms of how the mind constructs and assimilates knowledge. Gagné's theories, in particular, provide an interesting bridge between behaviourism and cognitive information processing (Davidson, 1998) but they can be seen to be quite firmly biased towards the former particularly with respect to the emphasis which they give to the design of instructional material.

Indeed the idea that instruction can be systematically designed is often attributed to Gagné and his work was very influential in the design of training materials (and it could be speculated that his philosophy of designing instructional material is very much influenced by this background). His instructional theory has three major elements. Firstly, it is based on a classification of learning outcomes, secondly it suggests that there are certain internal and external conditions which are necessary for achieving these outcomes and thirdly it expounds nine 'events of instruction' which serve as a template for developing and delivering a unit of instruction.

Gagné encouraged educators to think about the nature of the skill or task and the level which they expected students to achieve and to ensure that students had the necessary prerequisites to achieve that level. According to Gagné the way in which to determine the prerequisites for a learning task was to construct a hierarchy of learning objectives i.e. to analyse the task into a number of individual components. This is not done at a procedural level i.e. it is not simply a case of breaking down a procedure into a sequence of steps. The development of learning hierarchies is based around determining the intellectual skills which have to be mastered in order to complete each stage.

The construction of the learning hierarchy is central to Gagné's instructional design theory. The learning hierarchies provide measurable outputs and he asserts that these form the basis for the external conditions or actions which the instructor must arrange during instruction. They also support modification of the instruction process to take into account internal conditions, i.e. skills and capabilities that the learner has already mastered.

The events of instruction are nine steps which Gagné proposed as the conditions under which learning should ideally take place. These steps are quite clearly based on a behaviourist model for instruction and constitute – gaining attention, relating objectives, stimulating recall of prior learning, presenting the stimulus, providing learning guidance, eliciting performance and providing feedback. The direct correlation between Gagné's instructional events and development of educational software is described in Table 3.1.

Other theories and philosophies for the design of computer based instruction, such as Merrill's 'component design theory' (Merrill, 1993,1997; Merril and Twitchell, 1994), served to reinforce the application of the behaviourist approach and the production of courseware which complied with a four phase model involving presentation of information, guiding the student to a 'correct' interpretation of the information, practising by the student and assessment of student learning.

Whilst a number of authors obviously recognised the importance of what was termed 'learner-controlled instruction' (Cohen, 1983; Ross, 1984) it is equally obvious that the attainment of this goal was not being achieved in instructional design in the 1980s.

Table 3.1 Gagné's Nine Instructional Events applied to design of educational software

Instructional Event	**Type of CAL based instruction**			
	Drill and Practice	**Tutorials**	**Simulations**	**Educational Games**
	Supports practice for defined skills	Supports presentation of extensive bodies of information and interaction	Support the replication (or approximate replication) of specific tasks	Supports competitive procedures designed to inculcate or develop skills
1. Gaining attention	Title page to attract attention and introduction should allow student to select type of practice	Title page to attract attention and provide information on bounds of tutorial coverage	Scenario base needs to be established to describe context of the simulation and indicate procedures available for student to interact with or manipulate the simulation	Competition, fantasy and challenge are essential elements
2. Description of Learning Objectives	Goals and objectives of drill need to be stated	Statement of objectives given (behavioural objectives are encouraged by some authors)	Introduce student to the objective of the simulation and instructional goals	Game must have a goal – stated or inferred and rules to define actions allowed
3. Stimulating recall of prior learning	Focus of drills is to practice previous learning	Briefly provide a synopsis of related knowledge previously developed (pre-testing can be included)	Generally assume student has prior knowledge of the procedure being simulated	Design of game may require student to recall prior knowledge
4. Presenting the stimulus	No new content	Text, graphics, sound or combination	Discovery or experimentation approach	Constant flow of information on progress of game
5. Providing learner guidance	Practice of previous knowledge	Procedural and factual help (e.g. factual help to include examples, sample questions etc.)	Guidance is provided by the reaction or sensitivity of the simulation to student inputs	Guidance provided by game structure and rules

Table 3.1(continued)   Gagné's Nine Instructional Events applied to design of educational software

Instructional Event	Type of CAL based instruction			
	Drill and Practice	**Tutorials**	**Simulations**	**Educational Games**
	Supports practice for defined skills	Supports presentation of extensive bodies of information and interaction	Support the replication (or approximate replication) of specific tasks	Supports competitive procedures designed to inculcate or develop skills
6. Eliciting performance	Student can be given control over selection of examples to build up fluency and retention through practice	Most commonly by posing questions at various points during the tutorial and a final summative evaluation	Performance reflected in control over simulation	Games elicit a variety of types of performance depending on structure of game used
7. Providing Feedback	Immediate feedback for each drill item	Immediate feedback on reaction to questions providing opportunity for re-inforcement and correction	Feedback is immediate within a simulation and natural feedback of consequences of action are presented	Feedback on performance given throughout the course of playing the game
8. Assessing Performance	Learning reinforced by immediate feedback and remediation provided as part of a cycle of practice	Typically include an evaluation of ability to perform tasks established in learning objectives. Remediation is provided by more extensive presentation	Assess on the basis of being able to predict demonstrate an ability to identify key features essential to apply or understand the simulation in real life	Provide feedback to each player on the progress of the game and on individual performance. Supply information or 'hints' on how to play the game better.
9. Enhancing retention and transfer to other contexts	Provide examples which generalize the application of problem-solving drills to other contexts	Deepen levels of processing instructions by providing different strategies to remember key points and issues. Include aids to assist the student to incorporate new information with old.	Repetition of the simulation till student is familiar with the content. Simulation should provide good transfer because the student can use what is learned and apply it to real situations	Option to replay the game with the possibility of improving performance given application of what has been learned

Early attempts to provide adaptive instruction using CAL consisted of individually paced instruction and frame-based programs which although successful for some types of learning had limited ability to use graphics effectively and responsiveness to adapt to learner inputs was often limited to branching between static screens.

3.4 Benefits of Computer Assisted Learning

According to Ford, the two main forces which have driven the development of computer based learning systems are educational desirability and the possibilities opened up by technological developments. (Ford and Ford, 1992). In reviewing the literature concerning the introduction of early CAL systems into education one is drawn to the conclusion that in many instances developments in computer assisted learning have often been solely driven by the desire to use technology for its own sake.

Where the educational potential of such systems has been stressed the arguments presented for the benefits associated with the introduction of CAL are often indicative of the very limited educational advantages which such systems were designed to support.

The main advantages which are generally cited for use of CAL in teaching can be summarised as follows:

- The students progress through the material at their own pace;
- It is possible for the student easily to repeat the material if it is not fully understood the first time or for revision purposes just before examinations;
- The material can be delivered at any time. It is no longer constrained to a set lecture time;
- Developments in computer assisted learning materials open up potential for remote delivery of teaching.

In addition it has been argued that computer assisted learning can be viewed as having a positive influence in improving students motivation to learn. Some authors point out that the use of the computer itself as a novel delivery platform had a positive effect on student motivation and thus encouraged better acquisition of skills and knowledge. As Wills notes:

> *In almost all attitude studies, students have positive things to say about the design of the computer based learning materials and their potential to facilitate learning. (Wills and McNaught, 1996, p 110)*

Such studies, however, rarely attempt to explore this effect in detail. In addition this has to be balanced against counter claims that for some students the use of technology in teaching was seen to be a severely de-motivating factor. Again Wills notes that:

> *Student confidence level in using computers has been a factor in the past with some students expressing fears about using technology and being in a 'technologically alienating environment'. (Wills and McNaught, 1996, p.110).*

Finally it is important to note the significance of the economic argument – whether explicitly stated or assumed. There is often an assumption in the early literature surrounding CAL developments that if you examine the costs of production of the educational intervention you could provide cost analyses of the comparative benefits of the approach using CAL. This assumption, however, is often only treated tangentially in the literature and again while there are a number of studies which claim to have identified a quantifiable cost benefit (Fielding and Pearson, 1978; Tan and Nguyen, 1993) most studies are content simply to make reference to the 'potential' cost benefits of CAL. However, in their extensive meta-analysis of studies of the effectiveness of CAL, Kulik and Kulik report that there is no real evidence to justify (or refute) claims of cost effectiveness. As they note:

> *An early analysis by Levin Desterner & Meister (1986) suggested that nontechnological innovations, such as tutoring, produced results that were just as good at a lower cost. Later reanalyses, such as those by Blackwell, Niemiec and Walberg (1986), have suggested that computer-based instruction is not only a cost effective alternative to traditional instruction but that it is far more cost-effective than such non-technological innovations such as tutoring. Further work is needed on this important variable in instruction. (Kulik and Kulik, 1991, p.93)*

Examining the points outlined above, the argument for use of computer assisted learning based on a behaviourist approach obviously centres around the mode of delivery and the achievement of pre-defined learning outcomes. A diagrammatic model of the main features of this approach to CAL development is provided below (Figure 3.1).

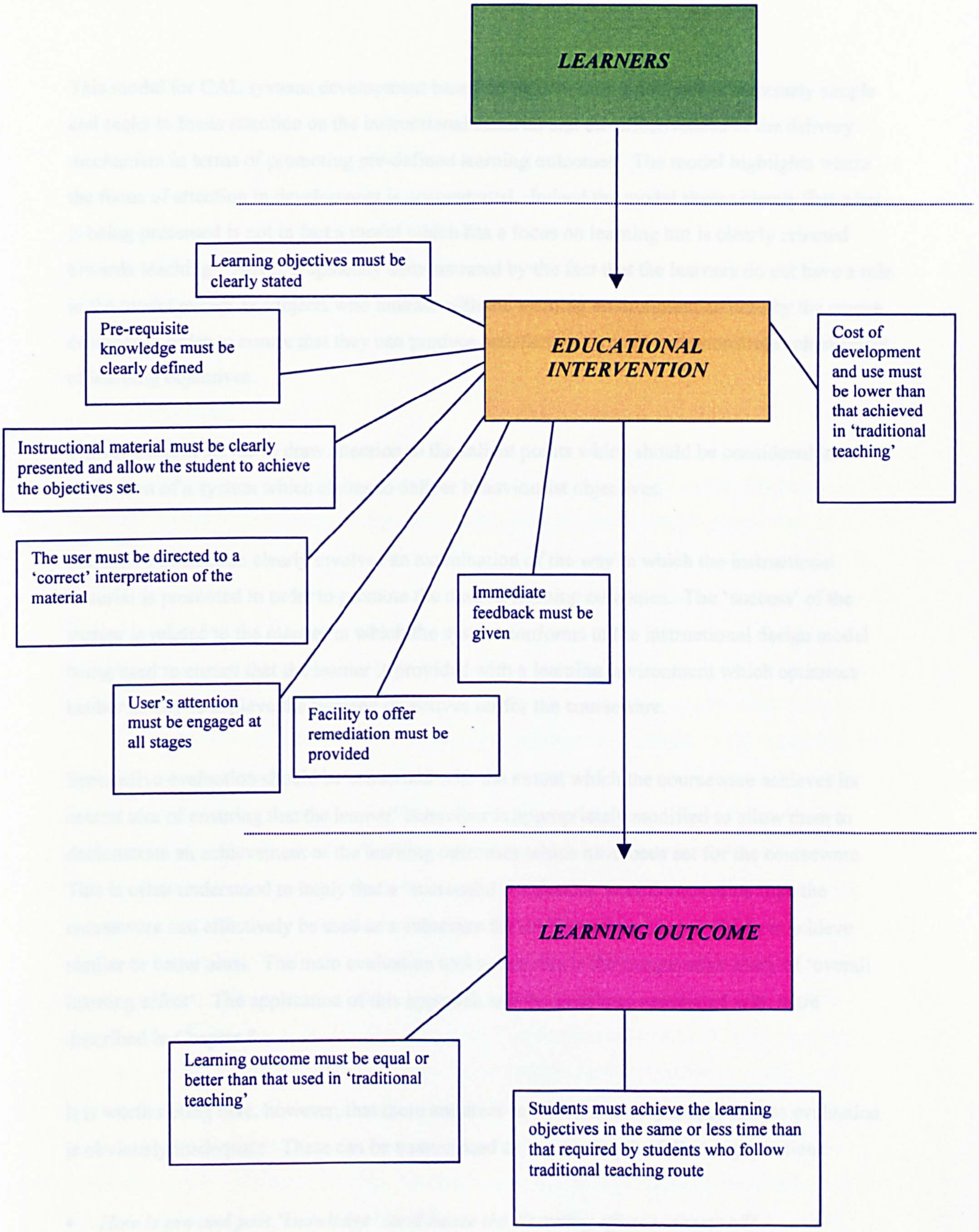

Figure 3.1 Model 1 – Behaviourist Model of a Computer Assisted 'Learning' System

This model for CAL systems development based on behaviourist principles is extremely simple and seeks to focus attention on the instructional material and the effectiveness of the delivery mechanism in terms of promoting pre-defined learning outcomes. The model highlights where the focus of attention in development is concentrated. Indeed the model shows clearly that what is being presented is not in fact a model which has a focus on learning but is clearly oriented towards teaching. This is graphically demonstrated by the fact that the learners do not have a role in the model except as subjects who interact with the learning environment created by the course designer in order to ensure that they can produce satisfactory outputs to demonstrate achievement of learning objectives.

The model also serves to draw attention to the salient points which should be considered in evaluation of a system which claims to deliver behaviourist objectives.

Formative evaluation clearly involves an examination of the way in which the instructional material is presented in order to promote the desired learning outcomes. The 'success' of the system is related to the manner in which the system conforms to the instructional design model being used to ensure that the learner is provided with a learning environment which optimises his/her ability to achieve the learning objectives set for the courseware.

Summative evaluation should be concerned with the extent which the courseware achieves its central aim of ensuring that the learner' behaviour is appropriately modified to allow them to demonstrate an achievement of the learning outcomes which have been set for the courseware. This is often understood to imply that a 'successful' evaluation must demonstrate that the courseware can effectively be used as a substitute for traditional teaching methods to achieve similar or better aims. The main evaluation tool to test this is the comparative study of 'overall learning effect'. The application of this approach and the problems associated with it are described in Chapter 8.

It is worth noting here, however, that there are areas in which this simple approach to evaluation is obviously inadequate. These can be summarised as concerning the following questions:

- *How is pre and post 'knowledge' (and hence the 'learning effect') measured?*

- *How can a realistic comparison between different types of educational intervention be achieved and in particular can such a comparison be designed to ensure that there is no experimental bias in favour of use of one approach over another?*
- *How is variation in reported outcomes of studies which use a comparative approach to different types of educational intervention accounted for?*
- *How is it possible to differentiate between factors which potentially affect the learner and those which we can attribute directly to the learning environment*

3.5 Conclusion

Behaviorism has its roots in Thorndike's Laws of Effect, readiness and exercise (practice), and Pavlov's Classical Conditioning theory. It is often contended that the implications of the behaviorist approach on instructional technology led to the design of piecemeal instruction with immediate feedback and reinforcement, drill and practice procedures, and self-paced programmed instruction all of which are now derided as educationally 'unsound'. However, it is important that we should not overstate the case against behaviourist principles in the design of instructional media. As Laurillard points out, within the limited objectives which it sets for itself, behaviourist principles have produced some very successful CAL packages (Laurillard, 1993). Many tried and tested robust educational programmes are derived from such principles and some authors still advocate a fairly rigorous behaviourist approach to instructional design. (See, for example, O'Toole, 1993). Reinforcement, feedback, practice and exercise can be seen to contribute directly to student achievement. The focus of behaviourism on the clear statement of learning objectives as a cornerstone for measuring the attainment of learning outcomes is currently recognised as a vital part of any educational intervention. It could also be argued that the concentration of effort on development of systems based on a behaviourist view of learning served to draw attention to the fact that there were significant inconsistencies in the reported outcomes of this approach to learning. It was in the attempt to solve problems which were apparent in these contradictory findings which stimulated a more 'user-centred' approach to designing instructional material. Such problems related, for example, to the failure of such studies to explain adequately the observed differences in individual performance (Marchionini, Neuman and Morrel, 1994; Steinberg, 1989). In addition there was a concern arising out of empirical studies which suggested that the use of highly directed, short step instruction with specific feedback tended to support only 'near transfer' of learning. That is, learning could be transferred to the examples and context in which instruction was given but could not be used to solve novel problems and be applied in more general situations. More critical attention was also evident concerning the need to develop 'deep' rather than shallow learning (Marton et al. 1994) and to examine ways in which this could be incorporated in computer based learning environments. In what they refer to as the 'dark ages of educational software' Feifer and Allender have criticised the fundamental basis on which CAL software was developed claiming that all too often learners were exposed to content without understanding the context in which it would be applied. This approach emphasises simply applying the correct label to a concept rather than using the concept in an appropriate situation. (Feifer and Allender, 1994).

The following chapter will review the development of the application of cognitive research in instructional design and in particular the basis for claims made that multimedia CAL provides a vehicle for developing systems which foster 'deep learning' and meaningful interaction with teaching materials.

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Chapter Four

Multimedia Computer Assisted Learning – Cognitive Approaches

'The purpose of education is to create men who are capable of doing new things, not simply repeating what other generations have done – men who are creative, inventive and discoverers'

(Jean Piaget, quoted in R.C. Ripple and N.V. Rochdale eds. Piaget Rediscovered, Ithica: Cornell UP, 1964)

4.0 Objectives

The objectives of this chapter are:

- to examine the development of multimedia CAL courseware and to define the characteristics of such packages
- to discuss the pedagogic basis on which claims for interactive multimedia learning have been based and to examine the features which such instructional material should exhibit.
- and thus to determine the factors which are important in a model of multimedia environments which are necessary to support the claims of multimedia CAL systems to deliver rich learning environments which are based on cognitive learning theories

4.1 Multimedia Computer Assisted Learning

The development of multimedia delivery systems and their use in the production of CAL materials has attracted a great deal of attention over the past decade. The potential benefits of using integrated multimedia environments for delivering teaching has prompted a number of claims that such systems will create a 'revolution in teaching and learning' but it is important that such claims should be rigorously investigated. This is particularly true because, despite the fact that a huge body of literature has been created which examines the development and design of such systems, there is a much smaller corpus of material which seeks to provide a critical evaluation of their effectiveness. Firstly, however, it is important to establish exactly what is meant by multimedia CAL systems and this proves to be more problematic than one might expect. In the introduction to a work discussing multimedia in higher education Deegan in attempting to define multimedia observes that:

> *'if the reader looks at a sample of definitions he or she may find that they differ a little from one another. If he or she then looks at some of the computer systems based on these concepts, they too will appear different from one another. Multimedia then, is difficult to define on paper and even within electronic systems based on multimedia it is sometimes not easy to see what are the unifying principles which make all of them part of this new medium" (Deegan, Lee and Timbrell, 1996, p.1)*

As noted in the introductory chapter to this work , Deegan is not alone, in finding it difficult to provide a coherent definition of multimedia.

However, it is obviously important in any study which seeks to evaluate multimedia computer assisted learning that these principles which characterize multimedia systems are very clearly delineated. Only by understanding the basis on which multimedia claims to provide an effective teaching environment will it be possible to evaluate systems based on these principles and in particular isolate the elements which can be properly attributed to multimedia structure or content.

The most frequently recurring concepts in the literature which are posited as factors which are important in explaining successful implementations of computer assisted learning packages based around the application of multimedia interfaces are:

- the advantages to be gained by using more than one medium for conveying information;

and

- the increased level of interactivity which it is possible to engage in when using multimedia packages (with consequences for allowing such systems to cater for individual learner differences).

These advantages are often implicitly or explicitly linked to the fact that the pedagogic approach which can be offered by multimedia CAL supports a cognitive approach to learning which stresses the importance of individual student control over learning and ability to engage the student more meaningfully in the learning process. (Ross, 1984; Becker and Dwyer, 1994; Oliver and Herrington, 1995; Thuring, Manneman and Haake, 1995)

Following on logically from the discussion of behaviourist approaches in the previous chapter, this chapter will provide a discussion of the benefits of computer assisted learning by examining the way in which the cognitive approach to learning has influenced developments in constructing computer based teaching materials. The implications of this for evaluation of such systems will then be discussed.

4.2 Historical Development

Hypertext systems allow the creation, annotation and linking of information from a variety of media. As such it has been contended that they provide a non-sequential and entirely new method of accessing information unlike traditional information systems which are primarily sequential in nature. They provide flexible access to information by incorporating the notions of navigation, annotation, and tailored presentation within a framework in which data is stored in a network of nodes connected by links. Generally the interface to hypermedia documents also incorporates link icons or markers that can be arbitrarily embedded with the contents and can be used for navigational purposes (Conklin, 1987). Such a system is constructed using a network of nodes (concepts) and links (relationships). A node usually represents a single concept or idea. Hypertext with multimedia is called "hypermedia". Thus a node can contain text, graphics, animation, audio, video, images or programs. Nodes are connected to other nodes by links. The node from which a link originates is called the reference and the node at which a link ends is called the referent. The latter are also referred to as anchors. The contents of a node are displayed by activating links which are pre-designed by the author to connect related concepts. Links can be bi-directional thus facilitating backward traversals. Links can be classified according to function e.g. specification link, elaboration link, membership link, opposition link and others. Links can also be classified in terms of the nature of relationship which may be referential (for cross-referencing purposes) or hierarchical (showing parent-child relationships).

In short, a hypermedia system is a database system which provides a totally different and unique method of accessing information. Whereas traditional databases have some structure around them, a hypermedia database has no regular structure (Nielsen, 1990a;1990b). The user is free to explore and assimilate information in different ways. Such a system incorporates a number of features which are summarised below:

1. A Graphical User Interface, with the help of browsers and overview diagrams, helps the user to navigate through large amounts of information by activating links and reading the contents of nodes.
2. An authoring system with tools to create and manage nodes (of multiple media) and links.
3. Traditional information retrieval (IR) mechanisms such as keyword searches, author searches etc. There are also attempts to incorporate structure queries along with content queries - retrieving a part of the hypertext network based on some user-specified criteria.
4. A hypermedia engine to manage information about nodes and links.
5. A storage system which can be a file system or a knowledge base or a relational database management system or an object-oriented database management system.

The development of multimedia systems are generally seen as arising out of the development of hypertext and usually the starting point for examining this is the seminal work conducted by Vannevar Bush. Bush's first article on the subject was published in the Atlantic Monthly in 1945 (Bush, 1945) and put forward the claim that methods which were then current for retrieving and processing information were not conducive to the manner in which humans ideally acquired information. Bush was concerned about the explosion of scientific literature which made it impossible even for specialists to follow developments in a field. He felt the need for a system that would help people find information more easily than was possible on paper. He elaborated on the principle of building 'associate webs' of information which would more easily match natural proclivities for searching and assimilating information. Bush designed a theoretical device (which could anachronistically be referred to as a search engine) which he called the Memory Extender (Memex) based on the idea of creating associative links between information which could provide a variety of 'trails of information' through an information space. The device was never constructed and indeed the technology available to Bush was not capable of supporting such a system but Rahm working at Brown University has used the original blueprints which Bush created to construct a working model of the system (Nye and Rahm, 1996). The drawings on which the system were based can be viewed at http://www.dynamicdiagrams.com. Though the system was never implemented, the concepts are still relevant to this day.

Bush's ideas were adopted by Nelson who claimed that published information in print form was necessarily sequential and as a consequence was not appropriate for representing non-sequential thought processes. (Nelson, 1965). In 1965, Nelson coined the word "hypertext" (non-linear text) and defined it as:

> *a body of written or pictorial material interconnected in such a complex way that it could not be conveniently represented on paper. It may contain summaries or maps of its contents and their interrelations; it may contain annotations, additions and footnotes from scholars who have examined it. (Nelson, 1965, p.84).*

Nelson clearly saw the potential which computers could provide in developing systems to allow the 'chunking' of information and subsequently providing efficient access to such 'chunks' via a network of links. Thus, in recent years, the essential feature of hypertext or hypermedia has developed around the concept of machine-supported links (both within and between documents).

Fig. 4.1 The Memex from animation designed by Dynamic Diagrams (available at http: ://www.dynamicdiagrams.com)

It was Englebart who first realised the theory in his work on the oN Line System (NLS)[1] online system. This system was used to store all research papers, memos, and reports in a shared workspace that could be cross-referenced with each other (Engelbart, 1962). This system demonstrated many of the features associated with later developments in hypertext systems – including the use of a pointing device to allow access to information stored in a series of conceptual hierarchies. Another very influential development was the FRESS (File Retrieval and Editing System) system which was produced at the Brown University Institute for Information and Scholarship and was developed collaboratively by van Dam and Nelson. This led to the development of Intermedia which was very influential in subsequent research in the field and was

[1] *Subsequently marketed unsuccessfully by McDonnell Douglas as AUGMENT.*

successfully used to support research and teaching at Brown University. Intermedia supported the concept of webs, composite entities that have many nodes and links between them. A link can belong to one or more webs. It provides three types of navigation tools: paths, maps, and scope lines. It supports shared and concurrent access to documents based on a system of access permissions (Yankelovich et al., 1988)

Many other innovative uses developments could be cited e.g. NoteCards (Halasz, 1988), Knowledge Management System (KMS) developed at Carnegie Mellon University (Akscyn et al., and HyperTies (Schneiderman, 1988). It was, however, the commercial development of hypertext and hypermedia systems for use on microcomputers which was to have the major impact on the development of CAL. Two of the most important systems were HyperCard which began to be marketed by Apple MacIntosh in 1987 and Guide, a hypertext system originating from work done at the University of Kent. The former was particularly influential because of the ease with which a variety of media could be incorporated into applications and the very simple interface which was provided. The Apple Macintosh was the first computer to provide multimedia capability as 'standard' and the fact that Hypercard was bundled free with the Apple computer was a contributory factor in promoting the development of HyperCard 'stacks' for a whole range of educational applications. The popularity of HyperCard is evident when one considers the huge number of applications which were developed using this software. Ambron and Hooper provide a catalogue of systems developed using HyperCard (Ambron and Hooper, 1988). By comparison development in IBM PC multimedia capacity was slower but the introduction and subsequent popularity of the Windows graphical user interface and standardisation of multimedia hardware and software using the MPC standard provided the impetus to develop applications for this platform. Guide was commercially marketed by Office Workstations Limited both on the IBM PC and Apple Macintosh. Text and graphics are integrated together in articles or documents. Guide supports four different kinds of links: replacement buttons, note buttons, reference buttons, and command buttons. Navigation through the replacement buttons initially provides a summary of the information and the degree of detail can be changed by the reader.

A major limiting factor on development of CAL which has been referred to in the previous chapter concerned the limitations of the technology used for delivery. Many of the reports on the introduction of CAL systems in the 1980s devote a section to the problems which were encountered with the hardware and subsequent problems for student use and evaluation. For a long time it can be seen that the design and use of computer based teaching applications was very much constrained by technological limitations. Indeed, it could be argued in many cases that the teaching objectives for some packages were a secondary consideration – the main focus of attention being on issues related to overcoming technical problems inherent in early computing environments. Design of CAL was a matter of what could be done rather than what should be done. However, as technology barriers reduced more consideration was evidently being given to the needs of the users of systems. Certainly by the early 1990s it was obvious that there were far fewer restrictions on how technology can be used to deliver learning.

In tandem with the developments in microcomputer software, in terms of the production of user friendly packages which could be applied in the creation of hypermedia courseware, there were a number of important advances in personal computing hardware that removed the main barriers to the creation of efficient and sophisticated learning environments. A key technology in this respect was the development of optical disk technology culminating in the introduction of the CD-ROM. This provided the basis for easy distribution of sophisticated packages which, because of the large file sizes resulting from incorporation of a variety of media, could not easily be distributed using conventional magnetic media. The enormous increase in efficiency of microprocessors, the expansion in capacity of memory, the development of sophisticated graphics and sound cards, and the huge increase in local disk storage offered by CD-ROM when coupled with a dramatic fall in hardware costs provided hardware platforms which offered huge potential for development. It was the advent of low cost microcomputing in the 1980s which engendered a spread of technology use into business and thence into education. Dramatic decreases in costs meant that the benefits associated with widespread use of the technology appeared to be increasingly attainable (Williamson, 1994). By the early 1990s sophisticated authoring systems were developed to take advantage of the capacity of the hardware. Products such as Authorware, Toolbook, Macromedia Director have now become established as tools within the higher education sector and are being used to deliver a range of very professional multimedia packages. More recent technological advances in digital graphics and sound and in particular in video production and editing have given these multimedia authoring systems capabilities that now provide the courseware designer with a huge array of choices for developing professional quality courseware.

4.3 Pedagogic Basis for Multimedia CAL

More significantly perhaps, the hardware and software developments were allied with a change in philosophy towards a cognitive approach to instructional design and there thus appeared to be considerable promise for significant developments in educational computer assisted learning packages. According to many commentators (Dwyer and Dwyer, 1994; Lieu and Reed, 1995; Roblyer, 1997; Spiro and Jehng, 1995) the most significant feature which is evident in hypertext/hypermedia approaches to developing computer assisted learning materials lies in the potential to provide a user-centred approach to learning as opposed to the instructor led approach adopted by early examples of CAL. Thus Deegan comments that:

> *Multimedia systems with their flexibility in terms of content, structure and degree of interactivity are, therefore, well suited to the new models of learner-centred education which are currently gaining popularity in Britain's schools and in higher education institutions.(Deegan, 1996, p.1)*

and more recently Sharma contends that:

> *Multimedia provides a higher level of mastery of the subject matter. It gives students 'hands on' learning, better retention, specific feedback and increased levels of understanding' (Sharma, 1999, p 12.)*

To be able to evaluate this contention and to provide a basis for being able to evaluate the products which deliver this 'learner-centric' courseware it is necessary to examine the basic features of the educational theories which it is claimed multimedia CAL can support. It may be argued that a knowledge of the learning process itself is not a fundamental prerequisite to 'good teaching'. However, when an attempt is being made to formalise the manner in which teaching is delivered using CAL packages and to design optimum methods for presenting it becomes imperative that the learning mechanism is more clearly expounded.

Many claims for the efficacy of multimedia CAL as an instructional medium have roots in cognitive theories which relate to perception and attention, memory, comprehension, motivation, transfer of learning and individual differences. The work of a number of educational theorists working in these areas is thus often cited to support the contention that multimedia CAL aids the learning process. The following section is not intended to be a comprehensive appraisal of all of the different theories and approaches that have advocated or contributed to the development of cognitive approaches to teaching and learning. Such an undertaking would be outwith the scope of this research. The intention rather is to discuss the contribution of key ideas on the subject and provide a framework for discussing the implications of this approach to learning to the evaluation of multimedia CAL systems.

4.3.1 Cognitive Approaches to Learning

One of the earliest examples of a cognitive approach being advocated in educational psychology is to be found in the work of John Dewey (Dewey, 1916). Like Thorndike, Dewey was also interested in the application of science to educational practice. However, unlike Thorndike, his scientific views were influenced not by connectivism but by an approach to the study of human organisms made popular by Darwin. As a result of this study, Dewey saw learning as an activity driven, not by reinforcement, but by the learner's sense of disequilibrium when presented with new experiences and ideas. For Dewey, if real growth was to occur the student must want to learn and be active in the learning process. He argued that the traditional reinforcement of information - given by the teacher, memorized and given back by the child - led only to superficial learning. The job of the teacher was to create an environment in which learners can and should be presented with problematic situations which they would be motivated to resolve by learning. While Dewey's thinking did not have a direct impact on early development of instructional technology, but his work served as an alternative framework for the study of learning throughout the 20th century and a great deal of later work in educational theory can be seen as attributable directly to some of his writing. (Nulden, 1999). In particular the idea that in order to provide "deep" or meaningful learning it is necessary to adopt a constructivist approach to the learning process can be traced back directly to Dewey. The cognitivist approach is characterised by the fact that the learner is central to the learning process and constructs new knowledge on the basis of prior experience and learning. This philosophy of learning emphasises the importance of involving the student actively in developing his or her own view of the subject and in questioning information which is supplied by examining the logic and reasoning behind the ideas being presented and relating them to previous experience or knowledge.

An important elaboration of Dewey's approach is provided when one examines the work of Piaget. Over a period of six decades, Jean Piaget conducted a program of naturalistic research that has profoundly affected our understanding of child development. Piaget called his general theoretical framework "genetic epistemology" because he was primarily interested in how knowledge developed in human organisms.[2] The concept of cognitive structure is central to his theory. Cognitive structures are patterns of physical or mental action that underlie specific acts of intelligence. Piaget referred to these cognitive structures as *schema* or *schemata.* Cognitive structures change through the processes of adaptation and involve what Piaget termed assimilation and accommodation. Assimilation involves the interpretation of events in terms of existing cognitive structure whereas accommodation refers to changing the cognitive structure to make sense of the environment. Cognitive development thus consists of a constant effort to adapt to the environment in terms of assimilation and accommodation. For Piaget there are two kinds of learning:

1. Learning which involves the acquisition of new responses to specific situations but without necessarily involving an understanding of the reasoning behind the learning

and

2. The acquisition of a new structure of mental operation from the 'equilibration' process i.e. the process by which the learner integrates change and experience to arrive at a new developmental stage.

The first type of learning is seen by Piaget as being transitory whereas the second type is viewed as crucial to development and leads to generalisations based on understanding. Piaget's work can

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[2] *Piaget's work was specifically concerned with a series of developmental stages in childhood. He was fundamentally a developmental psychologist concerned primarily with the theoretic analysis of successive ontogenetic stages. He did not set out to develop a specific theory of learning but the theories which he expounded have been applied more widely and are widely quoted in other works which deal with constructivist perspectives on learning.*

be seen to have strongly influenced the work of theorists such as Bruner and Vygotsky and is central to theories of intelligence put forward by Guildford, Gardner, Sternberg and others. (TIP theories http://www.gwu.edu/tip/piaget.html)

Piaget's work can also be seen to have influenced the development of a body of work which used ideas drawn from information processing theory as an alternative to behaviourist theory to explain the process of learning. These views are most evident in the writings of Anderson (Anderson, 1980;1990;1993) and in some of the later theories proposed by Gagné and Briggs. (Gagne and Briggs, 1992) Such theories attempt to provide a more detailed insight into the manner in which learners build mental models. A starting point in their work is an explicit distinction which is drawn between declarative knowledge and procedural knowledge. Declarative knowledge is factual knowledge about a subject (knowing that something is the case) whereas procedural knowledge refers to knowledge of how to perform a particular action or operation (knowing how to do something). Both types of knowledge have to be developed in any educational intervention - the degree and difficulty of doing so depending on the exact nature of the subject being studied and level at which the material is to be delivered. Declarative knowledge is generally categorised as being represented as propositions, images or linear orderings. The proposition is the basic unit of declarative knowledge and generally corresponds to a single 'idea' consisting of a topic or argument and a relationship which constrains the topic. These propositions are grouped into propositional networks from which we can make analogies and inferences. When working with spatial information, images provide an essential working memory representation of concepts and, in some instances may provide more powerful memory cues for organising and retrieving information. Finally linear ordering provides a structure of how information units are ranked or ordered to provide a logical framework within which deductions or inferences can be tested as valid. Individual knowledge appears to be an integration of these different elementary units which are organised into data structures referred to as schema. These schema provide a way of organising data structures in memory and encoding regular patterns. Schema provide a way of representing common categories of information and work to reduce the load on working memory and enhance the capacity to make 'intelligent' inferences.

Procedural knowledge may be classified as being either automatic or controlled. The former is the case when procedural knowledge operates with no awareness (e.g. when reading) and the latter when it is consciously using cognitive resources (e.g. when describing how to do something or thinking carefully through a particular task).

When new information is acquired it activates relevant prior knowledge leading to new propositions being stored in the declarative knowledge network. Elaboration is the process of adding new knowledge and relating it to existing knowledge. Some procedures, e.g. the use of analogies and provision of outlines, can be used to encourage elaboration. Similarly questions throughout a lesson can help to assist the process. If the new information cannot be assimilated students may become de-motivated or construct additional schema to deal with it. The 'good student' is one who can habitually use elaboration and organisation of new knowledge. The refinement of schema may make them more restrictive and in some cases may cause the recipient to completely discard or radically modify the previously held schema. Thus it is important to ensure time for reflection and consolidation of new knowledge and to prompt the learner to compare examples and note similarities. Likewise the procedures which allow the student to make use of declarative knowledge may be confirmed or refined as new knowledge is acquired. Having constructed a domain-specific procedural representation the student may require to fine tune procedures or adopt new procedures. It is important that with domain-specific procedures during the learning process the student maintains active control over use of the procedure. (This is unlike domain-general procedures where the automatic adoption of procedures is to be encouraged). The student must be able to use procedural strategies efficiently and one very important outcome of this is the development of transferable procedures, whereby the student can confidently apply existing procedural knowledge to deal with novel problem situations.

Bruner expanded upon Piaget's theories and linked them more closely to the development of a theory of instruction (Bruner, 1966;1973). A major theme in the theoretical framework of Bruner is that learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge. The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure to do so. Bruner's model of intellectual and cognitive development sees cognitive development as the individual's construction of a model of the world which allows the individual to deal with his environment.

Cognition is thus a way of knowing the world through reducing and organizing complexity to a form with which it can be deal with or used constructively. Cognitive structure (i.e., schema, mental models) provide meaning and organization to experiences and allows the individual to "go beyond the information given". He contended that:

> *for any idea or problem a body of knowledge can be presented in a form simple enough that any particular learner can understand it in a recognizable form' (Bruner, 1966 Quoted in TIP theories Online)*

and emphasized the need to focus attention on how this was to be achieved. He further contended that there are certain sequences or orders for presenting materials and ideas which are more likely to lead students to an understanding of principles but was careful to point out that for individuals there was no single prescriptive route. Thus, he states:

> *There is no single sequence for all learners and the optimum in many cases will depend on a variety of factors, including past learning, stage of development, nature of the material and individual differences. (Bruner, 1966)*

The manner in which the individual interacts with learning materials was also a concern of Ausubel (Ausubel, 1963; 1978a;1978b). Ausubel was more specifically concerned with how individuals learn large amounts of meaningful material from verbal/textual presentations. According to Ausubel, learning is based upon the kinds of superordinate, representational, and combinatorial processes that occur during the reception of information. A primary process in learning is subsumption in which new material is related to relevant ideas in the existing cognitive structure on a substantive, non-verbatim basis. (Ausubel contended that rote learning did not involve subsumption and, in contrast to Piaget and Bruner, he specifically excludes this from his discussion on cognitive structures). Cognitive structures represent the basis for all learning experiences and Ausubel was concerned to determine how learners could be encouraged to recognize and manipulate new information and integrate this with existing cognitive structures. It should be noted that Ausubel emphasized that subsumption involves reorganization of existing cognitive structures, not the development of new structures as is suggested by Piaget and Bruner.

'Existing cognitive structure is the principal factor influencing meaningful learning and retention ... Thus it is largely by strengthening relevant aspects of cognitive structure that new learning and retention can be facilitated' (Ausubel, 1978b).

An important instructional device which Ausubel proposes is the use of advance organizers:

These organizers are introduced in advance of learning itself, and are also presented at a higher level of abstraction, generality, and inclusiveness; and since the substantive content of a given organizer or series of organizers is selected on the basis of its suitability for explaining, integrating, and interrelating the material they precede, this strategy simultaneously satisfies the substantive as well as the programming criteria for enhancing the organization strength of cognitive structure. (Ausubel, 1963).

Ausubel emphasizes that advance organizers are different from overviews and summaries which simply emphasize key ideas and are presented at the same level of abstraction and generality as the rest of the material. Organizers act as a bridge between new learning material and existing related ideas.

4.3.1.1 Constructivism

The concerns of Piaget, Bruner and Ausubel, and others can be seen to have had powerful influences in the development of the theory of 'constructivism' as propounded by Jonassen and others (Duffy and Jonassen, 1992). Constructivists believe it is important to encourage reflexivity, the process whereby a student becomes aware of how their own thinking processes work. Helping students to think about how they are arriving at conclusions, or how they go about solving problems, may help to form more meaningful links between knowledge and develop more elaborate schemas.

Traditional theory focussed on the typical learner and what he would know when the course was completed. The constuctivist learner is not described. Instead, through metacognition, all learners are encouraged to reflect on their learning and how it fits into what they already know. Traditional theory specifies objectives for knowledge acquisition in advance. Constructivism attempts to identify the culture of a knowledge domain. For

> *example a constructivist learner would be encouraged to learn how to think like a historian, as opposed to learning dates in history. (Wilson, 1993, Online)*

Pedagogic scenarios based on this constructivist approach have attracted much attention recently. (Brown et al., 1989; Duffy and Jonassen, 1991). The basis is of all such theories is that knowledge is bound to the situation in which it is learned and in order to learn students must act in environments which replicate the real world (providing real expert guidance as much as possible) i.e. 'authentic environments'. Guidance at the context level is given by experts performing the activities, leaving students in the role of legitimate peripheral participant. Such systems are also being developed to provide a focal point for learning where students are being encouraged to interact in order to explore collaboratively a particular learning environment. In addition constructivists hold the view that reality is a shared process of social negotiation and thus stress strongly the importance of student interaction in the learning process.

Entwistle's comment, made over fifteen years ago, that "The future psychology of learning and teaching is certainly not likely to involve grand general theories of elegant simplicity" (Entwistle, 1985) is still apposite today. There is still a great deal of research which has to be conducted and considerable disagreement about the mechanisms which characterise 'successful' learning strategies. Nonetheless an analysis of the main trends in educational psychology over the last few decades demonstrates a convergence of views on the need to focus attention on the individual learner and in particular the cognitive processes by which the individual builds or changes his conception of a subject.

4. 3.2 Implications for Instructional Design

There is an obvious conceptual similarity in some early cognitivist theories and Bush's view of hypertext as an associative web of information which emulated the workings of the human mind. This has often been used to justify the validity of using hypertextual or hypermedia systems to support a cognitive approach to learning.

This is particularly true of cognitivist theories which emphasized the view that learning is a process of acquisition and re-organisation of cognitive structures or information processing theories (Good and Brophy, 1990). As Perkins notes

> *Information processing models have spawned the computer model of the mind as an information processor (Perkins, 1991, p.120)*

In both cases the direct parallels between information processing models and neural models of human brain activity has now been largely dismissed. However, the influence of cognitive principles in focussing attention away from instructional models which emphasised transfer of facts to one which focussed on understanding and assisting the procedures used by learners to assimilate new knowledge has been important.

A number of teaching approaches have been derived from cognitivist approaches. Notably, problem based learning (Boud and Felletti, 1991; Koschmann et al., 1994; Nulden and Scheepers, 1999), collaborative learning (Slavin, 1990), experiential learning (Gentry, 1990), case based instruction (Demetriadis and Pombortis, 1999; Jarz, Kainz and Walpoth, 1997), 'learner centred education' (Norman and Spohrer, 1996), and discovery-based learning (Jacobs, 1992), are all approaches which follow the logical consequences of adopting an approach to teaching and learning which emphasizes the role of the learner. Two cognitivist theories which are of particular interest in terms of instructional design are cognitive flexibility theory and minimalism.

Cognitive flexibility theory focuses on the nature of learning in complex and ill-structured domains. Spiro & Jehng (1990) note that:

> *By cognitive flexibility, we mean the ability to spontaneously restructure one's knowledge, in many ways, in adaptive response to radically changing situational demands ... This is a function of both the way knowledge is represented (e.g., along multiple rather single conceptual dimensions) and the processes that operate on those mental representations (e.g., processes of schema assembly rather than intact schema retrieval).(Spiro and Jehng, 1992, p.7)*

The theory is largely concerned with transfer of knowledge and skills beyond their initial learning situation. For this reason, emphasis is placed upon the presentation of information from multiple perspectives and the use of many case studies that present diverse examples. The theory also asserts that effective learning is context-dependent, so instruction needs to be very specific. In addition, the theory stresses the importance of constructed knowledge; learners must be given an opportunity to develop their own representations of information in order to learn. Cognitive flexibility theory is particularly interesting because it specifically addresses issues related to teaching with the support of interactive technology and there are some specific instances where direct reference is made to the manner in which practice must reflect theory . (Jonassen, Ambruso & Olesen ,1992). In particular hypermedia packages were seen as ideal vehicles for supporting the development and delivery scenarios to support user construction of knowledge.

Minimalism (Carroll, 1990) provides a direct challenge to behaviourist approaches to instructional design and, as the name implies, the approach is concerned with minimising the amount of explicit instructional material in order to promote 'natural' patterns of learning through hypothesis and experimentation. The theory was based on empirical evidence concerning the manner in which adult learners interacted with instructional materials in which Carroll contends that the learners were 'too busy learning to make much sense of the instructions' and wanted more meaningful interaction rather than simple drill and practice. Thus support for knowledge construction was advocated through the use of incomplete materials which encouraged improvisation and supported exploration and personal knowledge construction. In order to support this, error recognition and support for self correction was seen to be extremely important as a complement to permitting learners to 'learn through their mistakes'. To do this effectively implied the adoption of a highly modular structure of small scale learning units and learners should be provided with the freedom to determine the order and manner in which they tackled these units. The ideas behind minimalism were seen to have a natural affinity with the use of hypermedia as a tool to support learner control and interactivity. (Rosson et al. 1990).

As far as instructional design is concerned the main principle which recurs in a variety of cognitivist theories is the need for instructional material to try and encourage students to discover principles by themselves. This is in direct contrast to the analysis of content and pre-requisites advocated by Gagné and Briggs as an essential part of their instructional design system which was geared specifically to guiding learners through an optimum sequence of instruction. (Gagne and Briggs, 1992). The emphasis of this approach, therefore, is a move from an expository style of teaching to a more open or student centred environment. Thus situated learning is important, where students are encouraged to think about what real life people would do or feel in a particular situation. There must be active engagement in a dialogue (i.e., Socratic learning) and the task of the instructor is to translate information to be learned into a format appropriate to the learner's current state of understanding. However the instructor is no longer seen as occupying a central position in the learning process. Students are encouraged to consider the application of their learning to real life situations and to seek out as many alternative perspectives on a topic as they can find. (Wilson, 1997). Thus learning must be organised to ensure that learners continually build upon what they have already learned (Lebow, 1993) and engage in reflection on what and how they have learned. Cognitivist tools in instructional design can therefore be viewed as attempts to facilitate this process. Mergel discusses a number of significant approaches which have been engendered by the attempt by cognitivists to incorporate 'meaningful effects' in the development and delivery of teaching materials. (Mergel, 1999) and a number of other authors have contributed to the discussion of how cognitivist principles should influence instructional design. The following list of pragmatic actions has been constructed from the views of a number of prominent authors in order to summarise some of the important implications of a change in epistemological approach from behaviourism to cognitivism:

- Instruction must be concerned with the experiences and contexts that make the student willing and able to learn. Dewey comments that:

  > *'thoughts are incomplete. They are suggestions and standpoints for dealing with situations of experience. Till they are applied and tested in these situations they lack full point and reality'*
  > *(Dewey, 1916 quoted in Brockbank and McGill, 1998, p.24)*

- Instruction must be structured so that it can be easily grasped by the student (Bruner puts forward a theory of 'spiral organization' which attempts to explain how this can be done more explicitly)
- Instruction should be designed to facilitate extrapolation and 'filling in the gaps' in prior knowledge (going beyond the information given). (Bruner, 1966)
- Learning activities must provide multiple representations of content (Perkins, 1993)
- Knowledge sources should be highly interconnected rather than compartmentalized.

- Instructional materials should attempt to integrate new material with previously presented information through comparisons and cross-referencing of new and old ideas. (Gagne, 1985)
- Instruction should be case-based and emphasize knowledge construction, not transmission of information. (Gagne, 1985; Jonassen et al., 1993)
- Knowledge and skills should be taught in contexts that reflect the way the knowledge will be useful in real life (Brown, Collins and Duguid, 1989)
- Learning must be embodied in authentic tasks. Goal based scenarios or other task based approach should be integrated as a focus for learning (Schank et al., 1993; Sims, 1996)
- Learning should be collaborative (Wilson, 1997)

When we consider undertaking the same type of exercise and examine the implications of constructivism for instructional design we are immediately confronted by a paradox. Constructivism as a theory goes considerably further than other cognitivist theories and indeed challenges the approach of traditional instructional design at a fundamental level. Duffy and Jonassen have argued that instructional design theories have been largely based around an objectivist tradition in which knowledge is presumed to exist independent of instruction (Duffy and Jonassen, 1992). In the constructivist approach learning is viewed as a dynamic process in which the learner constructs their knowledge of the world.[3] Cunningham et al. have attempted to provide guidance on design of constructivist learning environments and provide a framework of seven main principles which should inform the design of these environments. These are defined in Table 4.1 below.

[3] *It should be noted that a common misconception of constructivism is the inference that we each therefore construct a unique reality and that reality is thus in the mind of the learner. However, Jonassen refutes this criticism on the basis that there is a physical world subject to physical laws which we all share a knowledge of in a roughly similar way but nevertheless we interpret this physical world and its objects individually and do so as a function of our experiences and beliefs. (Jonassen, 1991)*

Table 4.1 ***Seven Principles for Constructivist Design (From: Cunningham et al., 1993)***

Principles for designing Constructivist Environments	
1	Provide experience of the knowledge construction process
2	Provide experience in and appreciation of multiple perspectives
3	Embed learning in realistic and relevant contexts
4	Encourage ownership and voice in the learning process
5	Embed learning in social experience
6	Encourage multiple modes of representation
7	Encourage self-awareness of the knowledge construction process

Whilst this provides a useful summary of the main theory-based points of constuctivist design principles it is not particularly helpful in providing a direct link to features which must be overtly exhibited in constructivist learning environments in order to assist the student to construct their own view of knowledge. Other authors have provided similar lists of principles which characterise constructivist design (Grabinger and Dunlap, 1995: Jonassen et al., 1993). Many more have contributed to the discussion (Dick, 1991; Bednar et al., 1995; Khalsa, 1996; Lebow, 1993; Merril, 1991; Smorgansbord, 1996) and provide a variety of interpretations of what constitutes a constructivist instructional programme. Overall, however, these heuristics still appear rather vague, and much more specific advice on how to accomplish these activities is required for instructional designers to be able to design practical constructivist environments. As Jonassen notes:

> *The conundrum that constructivism poses for instructional designers, however, is that if each individual is responsible for knowledge construction, how can we as designers determine and insure a common set of outcomes for learning, as we have been taught to do. (Jonassen, 1995, Online.).*

The complexities and at times contradictions of the constructivist paradigm have led some authors to question whether instructional design principles can be derived which adequately encompass the development of completely 'open' systems which are a pre-requisite for developing purposeful knowledge construction. Viewed objectively there is considerable weight to the argument that constructivism is a learning theory more than a teaching approach. Furthermore Bostock has questioned the practical application of constructivism to mass higher education noting that:

> *Mass higher education often has limited resources, increasing student/staff ratios, increasing diversity of student types and 'legacy systems' of time-tabling and assessment (Bostock, 1998, p.225)*

Significantly also it should be noted that it is very difficult to provide any basis for evaluation of constructivist environments given that their aim is to promote an 'open-ended' learning experience and, if successful, the results of the learning experience may be unique to each individual learner.

Cognitive approaches to learning (and specifically constructivist models) are currently the dominant paradigm in educational psychology. They have given rise to a great deal of interest in adopting a cognitive view which lays considerable store on the learner's need to build internal representation of knowledge through their involvement in learning. There have been a number of claims made that the principles outlined above can be embedded in interactive multimedia CAL and it is now important to examine the basis for these claims.

4.4 Benefits of Multimedia CAL

In the literature the claims made that multimedia CAL supports a cognitive approach to learning are often linked uncritically to the view that such systems can promote deeper learning than did earlier CAL systems which simply provided a mechanism to encourage the rote learning of facts. The crucial question to be asked now is why it is contended that multimedia CAL programmes can deliver all or some of the benefits associated with a cognitive approach to learning. Before attempting to evaluate particular instances of multimedia CAL the main features of such systems which differentiate them from other teaching modes need to be clearly identified. This is important in order to develop a set of critical success factors which relate in particular to the delivery medium and not to other variables which may be functions of the particular circumstances associated with instances of use of such systems.

An analysis of the literature shows that there are clearly two main considerations on which the case for multimedia CAL is based. These are:

- the advantages to be gained by using different media for conveying information and
- the increased level of interactivity which it is possible to engage in when using multimedia packages (with consequences for allowing such systems to cater for individual learner differences)

4.4.1 Multimedia

At the simplest level multimedia can be seen to offer pedagogical advantages because of the variety of media used to communicate information. The ability to present information to take best advantage of the natural information processing capacity of the recipients of that information appears so obvious that for many commentators on the subject it requires no justification. Even when images or actions can be accurately described in words the information processing overheads of using text can be reduced by providing an image, sound or video-clip to allow the user to comprehend and assimilate the information more quickly.

An educational theory that is of particular relevance to the design of instructional materials is the symbol systems theory which was developed by Salomon and is intended to explain the effects of media on learning. Saloman (1979) states:

> *To summarize, the symbol systems of media affect the acquisition of knowledge in a number of ways. First, they highlight different aspects of content. Second, they vary with respect to ease of recoding. Third, specific coding elements can save the learner from difficult mental elaborations by overtly supplanting or short-circuiting specific elaboration. Fourth, symbol systems differ with respect to how much processing they demand or allow. Fifth, symbol systems differ with respect to the kinds of mental processes they call on for recoding and elaboration. Thus, symbol systems partly determine who will acquire how much knowledge from what kinds of messages. (Saloman, 1979)*

Thus it is posited that each medium is capable of conveying content via certain inherent symbol systems. For example, Salomon suggests that television requires less mental processing than reading and that the meanings secured from viewing television tend to be less elaborate than those secured from reading (i.e., different levels of processing are involved). [4] The symbolic coding elements of particular media require different mental transformations and hence affect the mastery of specific skills.

Arising out of theories such as Saloman's, and prompted also by a debate within the field of educational technology on the effectiveness of different media in teaching, (Clark, 1994a; 1994b) a large volume of literature has evolved. The main basis of this is concerned with the manner in which different media types and combinations of media types are effective in conveying particular types of information. The fact that multimedia offers concurrent access to a variety of media formats is also generally held to be a positive factor when discussing their potential to enhance learning. The basis for this contention, however, often rests on a fairly uncritical approach. Often in the literature discussing the potential for multimedia systems there are references to Treichler's assertion that 'People generally remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they hear and see …' (Treichler, 1967). This is not a set of figures based on empirical evidence but nonetheless appears to have become established as a 'fact' in the literature which seeks to justify the development of multimedia systems in learning. There are a number of studies which, using much more robust methodologies, have attempted to look at the potential gains from instructional methods which combine different media. However the majority of work in this area has centred on primary education. Such work is therefore open to question on the basis that the support provided for text by either graphics or sound was in fact a function of the subject's ability to process text based information. In order to examine this topic further a simple experiment was conducted as part of this research. The objective of the experiment was to assess the impact of using a multimedia interface which offered graphics, text and sound as a means of acquiring information on students' ability to acquire and retain information. The conclusion of the experiment (described in detail in

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[4] It is interesting to note that Salomon also argues that schema play a major role in determining how messages are perceived in terms of creating an anticipatory bias that influences what information is selected and how it is interpreted and his work has interesting parallels with the work of cognitive psychologists such as Bruner and Ausubel. His work is of critical importance for those working in the CAL field and for multimedia designers (see for example Salomon, Perkins & Globerson, 1991).

Chapter 11) was that the use of graphics significantly assisted learners in the short term but that these learners showed no significant gains in the longer term.

Thus there appears to be empirical support for the idea that using multiple media assists the acquisition and short term retention of information. From a theoretical viewpoint there also appears to be some merit in the idea. According to the dual coding theory (Paivio, 1986; 1991) information is processed through one of two independent channels. One channel processes verbal information (either textual or speech) and the other nonverbal information (such as graphics or sounds other than speech). Paivio's argument is that learning is better when information is referentially processed through two channels rather than one as the learner can create more cognitive pathways for subsequent retrieval of the information. This theory also allows us to explain some of the seemingly contradictory findings presented in the literature. Najjar reviewed studies from a wide range of fields to find out whether there is support for the assumption that presentation of information using a variety of media helps people learn more effectively (Najjar, 1996) but results from the literature he examined show a range of findings from studies which showed no significant effect to those which showed a highly significant difference. In order to make sense of this finding, however, it is important to differentiate studies which set out to examine the complementary use of media types which assist the processing of verbal and non-verbal information as opposed to those studies which simply compare the presentation the same or very similar formats and seek to identify differences associated with the use of two media types which are processed by the same channel. Thus we should not be surprised by the results reported in studies such as that by Hegarty (Hegary et al., 1999) who, when attempting to explain a theoretical model which they had developed relating to comprehension gains associated with the use of graphics, could find no significant learning effects in empirical studies comparing still graphics and animated diagrams (both focus on use of non-verbal channels). Similarly Scaife and Rogers examination of the manner in which graphical information is used by learners shows that there is no real evidence which can be used to support guidelines on appropriate use of different types of graphics. Parkes' work on the different cognitive overheads associated with the use of 'analogical' or actual relations and 'fregeian' or symbolic representations shows some evidence that higher cognitive processing overheads are required to support the latter type of graphic but his work did not specifically test the impact of this on use in multimedia systems (Parkes, 1994). Shih and Alessi in an experimental study of the relative advantages of text and voice on learning in multimedia courseware noted that 'redundant audio may even result in a negative effect' (Shih & Alessi, 1996). Thus it would appear that there is some evidence that the use of multiple media enhances learning only if it supports dual coding of information although it should be noted that even in such cases the issue is not fully resolved in the literature. Clark and Craig suggest that dual coding theory has not been adequately supported by subsequent research (Clark and Craig, 1992) and Reeves cites many references criticising media comparison and media replication research. (Reeves, 1987).

Given the discussion above it could be argued that the solution to designing effective multimedia systems is to provide the learner with a variety of different 'representations' of information using a variety of media. The learner can then elect to choose the particular media format which they feel is most appropriate (e.g. a graphical interpretation of text could be presented on demand, sound can be invoked or turned off, a video sequence could be launched etc.). Whilst this is theoretically possible, when one examines the manner in which multimedia courseware have been created, the extent of choice provided in relation to use or non-use of particular media is fairly limited. The underlying assumption in the construction of such courseware is generally one which emphasises the author's approach to use of different media rather than being concerned with the need to provide flexibility for the learner. At an early stage of courseware production the designer has often already decided upon a particular medium for parts of the courseware. This assumes that the author of the multimedia package has determined which medium is most appropriate to convey a particular message.

Thus a number of researchers have been concerned with considering whether it is possible to provide guidelines for instructional designers on the most effective medium to represent specific information. This indeed has been a concern of educators for almost a century now. Reiser and Gagné note that much of this interest in media selection arises out of an implicit belief that teaching can be conducted more effectively and efficiently by appropriate use of different media types (Reiser and Gagné, 1982) and in support of this quote Thorndike's assertion that

> *A human being should not be wasted in doing what forty sheets of paper or two phonographs can do. Just because personal teaching is so precious and can do what books and apparatus cannot, it should be saved for its peculiar work. (Thorndike, 1912 Quoted in Behaviourism as a Learning Theory, Online)*

Reiser and Gagné discuss a range of media selection models (Reiser and Gagne, 1982). It is important, however, to be cautious when using such sources which aim to give fairly proscriptive guidance on which medium should be adopted for different learning situations. The current educational culture is still very 'logocentric' i.e. a culture which emphasises the value of talk and written language to the near exclusion of any other mode of representation. (Cunningham, Duffy and Knuth, 1993). Thus as Najjar notes:

> *Although media selection models based on learning objectives (e.g. Arens, 1992, Arens, Miller, Shapiro & Sondheimer, 1988), communications goals (e.g. Elhadad, Seligmann, Feiner & McKeown, 1989; Feiner & McKeown, 1990; 1991) or learning characteristics tasks and instructional settings (e.g. Reiser & Gagné, 1982) are available, these models appear to be based on experienced judgement rather than on empirical studies' (Najjar, 1996, p.138)*

One could add to this list the work of Clark, Kozma, Ullmer, Dwyer, and Romiszowki. (Clark, 1985;1994a;1994b; Kozma, 1994; Dwyer, 1978; Romiszowski, 1974). The underpinning for a view that a particular media resource has an inherent value irrespective of the context of its use and the individual preferences of users is not tenable.

As discussed above, the claims for multimedia's effectiveness in learning, therefore, rely on how different media are used rather than how many different media are used. The guiding principle which needs to be considered is that media are used which are appropriate to the pedagogical objectives of a particular course or part of a course of study. (Though it is worth noting that on reviewing a broad spectrum of multimedia CAL packages a large number of cases can be found in which the media sequences or graphics appear to have been used purely to illustrate or adorn the textual material rather than having been designed explicitly to be integrated with the pedagagocial objectives of the package).

Thus in terms of evaluation it is important to look beyond the presence or absence of multimedia features and to examine the appropriate use of different media to support specific pedagogical objectives. Additionally, it is important to examine the manner and degree of choice offered to users with respect to activating or using different media. This latter point is supported by the theories developed by Salomon and described above. One of the critical concepts of Salomon's theory is that the effectiveness of a medium depends upon its match with the learner, the context and the task. The implications of this in terms of instructional design are that the level of knowledge and skill that an individual possesses will affect the impact of specific media sequence and also that the nature of the learning/information processing tasks can affect the impact of specific media sequences. Thus multimedia packages must support learner control and choice. This, of course raises the question of the extent to which we can assume that the learner is able to make an informed choice as to which medium supports the most effective learning strategy. This is an issue which is not confined to media selection but which is central to the manner in which users interact effectively with the teaching material as a whole.

4.4.2 Interactivity

Interactivity can be considered to be the mutual action between the learner, the learning system and the learning material. Barker, further notes that interactivity in learning is 'a necessary and fundamental mechanism for knowledge acquisition and the development of both cognitive and physical skills' (Barker, 1994). At a very basic level interactivity might simply refer to the use of a range of input devices to activate the technology being used and provide a result in an output. This level of definition, in terms of human computer interaction simply asserts that interactivity is any sequence of actions undertaken by the user in order to evoke a response from the system. Damarin (1982) identified a series of options or categories of interaction such as watching, finding, doing, using, constructing and creating. Others have provided similar categories (Ambron and Hooper, 1988). In the literature we find a discussion on interactivy which parallels the discussion on how media might influence learning. At a very basic level this manifests itself in debates which centre around the categorisation of particular media or methods as being either active and passive. This approach is well illustrated by an interesting listserv debate which was instigated in May 1996 by a paper which Laurillard put forward which stimulated a discussion of the nature of learner activity. Having asserted that traditional 'attending' activities (e.g. lectures and reading) were insufficient for a sound education a discussion ensued in which it became obvious that from certain viewpoints reading could in fact be regarded as interactive rather than passive. It was suggested, however, that learners have to be encouraged to become 'active'

readers. Thus as with the discussion above on the influence of media on learning it is more profitable to concentrate on how interactivity is promoted rather than become bogged down in the issue of whether certain types of media inherently require more interaction than others.
As Bork notes (Bork, 1992) instructional technology must concern itself with making that interaction both meaningful and engaging to the user. In this the developer of CAL material is no different from the lecturer, the author of a textbook or the producer of a video. In a CAL learning environment interactivity has to be seen as a function of the input required by the learner, the response by the computer and the analysis of how these interactions build the user's understanding of the subject being studied. Thus as Jonassen asserts:

> *Generally the quality of the interaction in microcomputer courseware is a function of the nature of the learner's response and the computer feedback. If the response is consistent with the learner's information processing needs, then it is meaningful (Jonassen, 1995, Online).*

An analysis of multimedia CAL packages themselves demonstrates that there is a huge range of methods which are used in support of different types of interaction - ranging from simple screen controls for page turning to the provision of complex control tools for controlling simulations.

The following table (Table 4.2) derived from literature on interactivity (Alavi, 1994; Bland; 1995; Leidner and Jarvenpaa, 1993) and from an examination of multimedia CAL systems attempts to summarise some of the means by which meaningful user interactions can be encouraged in CAL environments.
Paradoxically, whilst there is general agreement that interactivity is required in multimedia CAL systems there is little consensus on exactly what is meant by the term. What is required in order to make sense of the plethora of types of interaction is a general taxonomy of interactivity. Several authors have attempted to do this (Rhodes and Azbell, 1985; Jonassen, 1988; Swchweir and Misanchuck, 1993; Sims, 1996). Rhodes and Azbell bias their discussion towards navigation controls. Jonassen identified five levels of interactivity which focus on user involvement with the application but does not discuss in detail issues other than learner control. His discussion, however, is very abstract and made less clear by linking discussion of possible outcomes of different types of interaction with a discussion of how these affect the quality of learning.

Table 4.2 Devices used to support interactions in CAL programmes

EXAMPLES OF DEVICES USED FOR INTERACTION IN MULTIMEDIA CAL
1. Controls for page turning and navigation to start and end of sections
2. Provision of menus to allow direct access to sections or chapters
3. Buttons to provide definitions, references and explanations
4. Glossaries and thesauri linked to hotwords
5. Online assessments (formative and summative)
6. Providing facilities for note taking
7. Multiple choice assessments
8. Click and drag activities to simulate construction of tool or mapping of concepts into a logical order
9. Labelling of diagrams
10. Identification of an item from a graphic or diagram
11. Working an example by splitting it into component parts
12. Selection of options from multiple list boxes
13. Navigation to resources outwith the multimedia CAL package (Web sites or information resources or databanks held on-line)
14. Inclusion of questions to encourage reflection on points made or to raise queries which encourage students to see the problem in a different light
15. Activation of sound files, graphics or video
16. Control buttons to control playback of sound and video
17. Simple text entry (associated with assessment)
18. E-mail links to teaching staff to feedback comments or queries
19. Virtual 'coach' or guide to provide help either on request or in response to incorrect input
20. Timed responses for answers in order to develop speed and proficiency
21. Complex text entry
22. Navigation aids such as concept maps to orient the user and highlight context in which parts of the document are presented
23. Full text search for keywords or phrases
24. Simulation of activity in which variables which determine outcome can be modified which will change the outcome of the activity
25. Full simulation of a process or activity with options to amend inputs to the scenario using controls which emulate physical controls to view directly the effect of such changes

Schweier and Misanchuck concentrate on separation of interactivity on three dimensions (Schweier and Misanchuck, 1993) and seek to separate issues related to adaptive control of content by the system, navigational and elaboration functions and physical transactions (such as use of mouse or keyboard). Sims concentrates more on practical aspects of developing interactive controls (Sims, 1996). Draper has questioned the relevance of categorising learner interactions on the basis that:

> *The crudest are overtly machine-centred, that is they categorise interaction with humans in terms of a machine's technical characteristics ... The basic reason they are attractive to both computer scientists and to psychologists who like to measure overt behaviour is just that: overt physical actions by humans or machines are unproblematic to observe and record. (Draper, 1996, Online)*

However, not all classifications are provided at this basic level. The following discussion is centred on a comprehensive classification provided by Shadroff (Shadroff, 1999) and is illustrated in Figure 4.2 below. Shadroff highlights six major factors which contribute to an interactive online environment. (Shadroff, 1999).

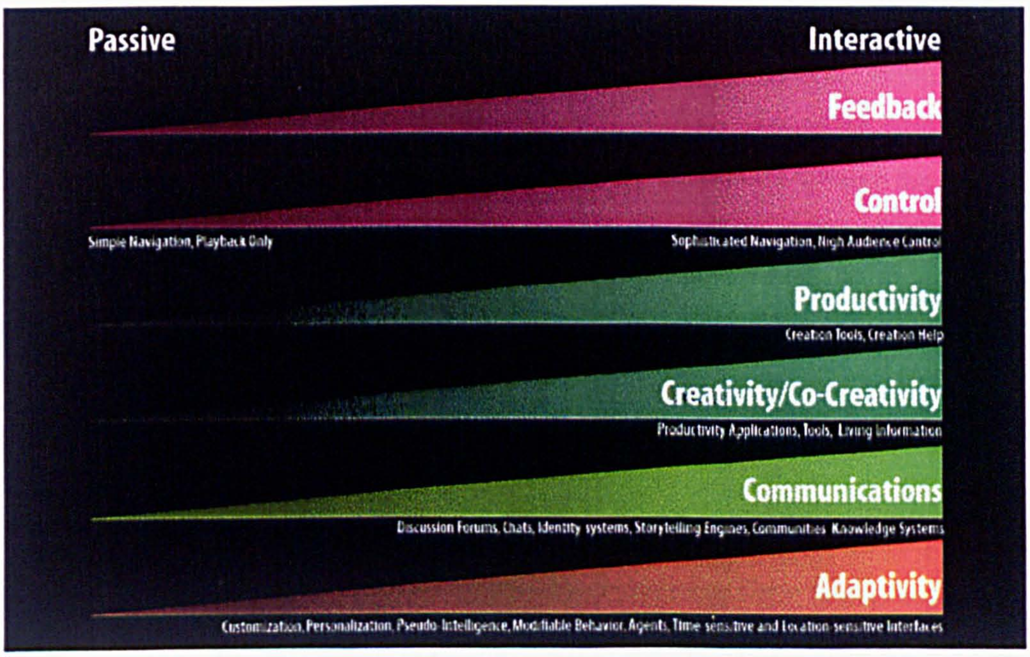

Figure 4.2 The Interactivity Spectrum (from Nathan Shadroff, www.nathan.com.thoughts)

Shadroff does not expand on the manner in which the different types of interactivity can be incorporated into learning environments but it is possible to see that the types of category which he has established are directly relevant to the educational process and have strong similarities with many of the concepts discussed by Reeves, Laurillard and others when discussing instructional design. The aspects of interactivity identified below are all important and must be supported in any learning environment. **Feedback** to learners is obviously a crucial activity in teaching and learning. The behaviourist approach discussed in Chapter Three emphasised the need for immediate feedback to learners mainly in the context of encouraging the learner to change his/her behaviour in order to guide them to the 'correct' response. As Laurillard comments:

> *'Action without feedback is completely unproductive for the learner. As we learn about the world through acting upon it there is continual feedback of some kind ... '. (Laurillard, 1993).*

Laurillard further elaborates on the distinction between intrinsic feedback which is a natural consequence of an action and extrinsic feedback which is an external comment on the situation (usually in terms of categorisation of the action as being right or wrong). Both types of feedback, delivered in an appropriate format, should be employed in the design of learning environments (Alessi and Trollip, 1991). **Productivity** can be improved by providing the learner with a range of tools to help him/her make best use of the teaching material presented in the multimedia package. Good examples of this include the provision of help files, note taking facilities, on-line dictionaries and glossaries. **Creativity and co-creativity** can be fostered through the use of simulation and role play in the learning environment. It is often assumed that collaboration is really only possible in networked multimedia environments but in fact when investigating the use of an experimental stand-alone CAL package (discussed in the second part of the thesis) it was found that in the laboratory students would often prefer to work in groups and discuss the material which was being presented. Communication is crucial to the design of learning environments and an essential feature of any CAL system must be the provision of a two way channel of communication between the learner and instructor. If this is not explicitly designed into the CAL software then it must be provided outwith the package either when the package is being used or immediately thereafter. **Adaptivity** refers to the manner in which the learning environment can change in response to the needs of the learner. In a real life teaching situation there are obviously many occasions on which the lecturer or instructor will adapt what is being taught in order to accommodate verbal or non-verbal cues from learners. Thus additional material at a different level may be presented or material which appears to have already been comprehended will be discarded. Likewise the pace and level of learning will be adjusted to reflect the needs of the users. Though this characterises all learning situations it is particularly evident in small group work and tutorials. Adaptivity may be incorporated into CAL packages at a very simple level. The learner may be able to choose alternative branches or pathways through the program or as a consequence of failure to complete assessments satisfactorily the learner may be forced to repeat a part of the package or undertake remedial work. Ideally, however, adaptive CAL should go much further in providing the learner with a customised learning environment which is receptive to their individual level of understanding of the material and their personal or preferred style for interacting with the learning material.

Finally there is the question of user **control**. The rest of this discussion of interactivity in the context of multimedia CAL systems concentrates on the question of user control because this single feature is often cited as the central feature which is distinguishes hypertextual and hypermedia learning environments from earlier linear CAL programmes.

4.4.2.1 Support for user control

It is often stated that an important advantage of multimedia CAL systems is that instruction tends to be much more interactive than traditional classroom lectures. This is rarely disputed in the literature. At the simplest level interactivity can be seen to be enhanced by the provision of facilities to allow users to navigate their way through the learning material in different ways. Thus, the fact that hypermedia systems are inherently flexible in permitting the construction of a network of nodes and links to represent knowledge in a particular subject area has given rise to a general assumption that these systems will inevitably be useful in providing effective interfaces for student centred learning and can therefore address the problem of catering for a wide range of student approaches. While Bush's original claims that an "associative web" of information accurately reflects the way in which the mind gathers and assimilates information has now been clearly discredited some unsupported claims are still being made in the literature which reflect this view. Swan, for example contends that multimedia systems can

> *'physically represent ways that model the cognitive representations characteristic of critical thinking in ill structured domains, perhaps human thinking in general.' (Swan, 1994, p.120).*

Though few would support this argument there is still a general assumption that the level of student control over learning which can be offered by a hypermedia database has potential advantages in the learning process. However, it is important to examine such assumptions critically. In particular there is evidence in the literature of a concern about the need to clarify the situations in which hypermedia/hypertextual linking can best be used when attempting to ensure that users can quickly make sense of the various options presented to them without creating problems of 'cognitive overload' associated with the process of determining the ideal path through a complex web of information. A number of studies have been made to attempt to define conditions under which hypermedia systems perform best. Thus, for example, it is contended that:

> *simple hyper-systems tend to be more successful than complicated branching networks; particularly when the only way to change route through the information was by backtracking (Jaques, Nonnecke, Preece and McKerlie, 1993, p.219)*

and further that hypermedia is:

> *best for information systems that are small enough ... and familiar enough to users to let them find their way around (Nielsen, 1989)*

Commenting on these views of how users can best be assisted to interact with hypermedia systems MacKenzie notes cynically (but with justification) that:

> *In other words, a good map describes an area so familiar that you have no need to consult it; an even better one is of a tunnel with only one entrance and exit (MacKenzie,1996, p.121)*

In cases other than very limited homogeneous subject areas several commentators have indicated that in practice the problems of disorientation and navigational uncertainty may in fact outweigh the potential gained from the flexible manipulation of different media. (Conklin, 1987; Dix et al., 1998; Meehan and Shubin, 1997).

To put the debate into perspective it is important to be aware when reading the literature of hypertext and hypermedia that the issues related to problems with navigation cannot be generalised. They need to be seen in the context of the purpose or function of the system being developed. In particular the issue of user disorientation (as a design concern when developing educational software) must not be confused with the issue of provision of learner control (as a pedagogically desirable feature of educational software). Thus for example in terms of the user becoming lost in the structure of the hypertext or hypermedia it is quite legitimate to see the issue of navigation as being a major problem for systems which are developed as large scale databases or macro literacy systems. However, in the vast majority of courseware packages the volume of material to be covered is not so extensive as to present a real problem. Moreover, a variety of solutions to structuring courseware to make it easy for students to track their progress and maintain a clear sense of how to navigate through the courseware have been developed, tested and found to be effective[5]. In using the multimedia CAL interface, students need to be able to clearly identify the choices which are available to them and easily recognise the various tools provided to show links between conceptually related topics and additional illustrative or explanatory material. Thus the question which has to be addressed in relation to hypermedia courseware design in education relates to the fact that students must be given detailed guidance on the manner in which they can gain access to all of the resources available. In addition some form of indication is required to show what is core to the teaching and assessment of a particular area and what can be regarded as peripheral. Commonly tools are also provided to assist learners to gain an overall impression of the range and complexity of the package being used (via maps of the structure or 'progress indicators' to show the percentage of the topic covered). Hotwords and icons for additional information need to be provided and the manner in which graphics, video or animation sequences can be accessed has to be transparent to the users. The instructional designer may also provide controls to mediate the level of detail which is displayed, the option to review sections of the material, choice over when to take an assessment on the material studied, a tool to take notes or make annotations on the material presented, and to the opportunity to feed back comments or questions to the tutor. Not all such facilities are available in multimedia courseware and the more of them which are implemented the greater the challenge for the designer in terms of designing a suitable interface in which the structure of the materials presented is clearly evident to users.

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[5] *Interface design is considered in more detail in Chapter 10 where there is a description of the development and formative assessment of the demonstrator CAL material prepared as part of this research*

4.4.2.2 Learner Control

The above discussion focussed on the mechanics of how multimedia systems can provide the user with control. A more fundamental issue for design of navigation in the context of educational multimedia , however, is the degree of flexibility which *should* be offered to learners to permit them to explore the material. Merrill uses the term to refer to the degree of freedom the user has to manipulate the learning environment in order to create an individual path through the learning material. For more than thirty years various authors (e.g. Mager, 1964; Oliviera, 1990) have argued that learners who exercise control over their own learning are more motivated, can more easily relate new information to their personal knowledge, and can adjust pacing to personal abilities. As noted above there are a large number of tools by which control can be provided to support the learner but there is still some debate over how they should be used. In assessing multimedia CAL systems which claim to be based upon cognitivist theories of learning it would be expected that such features would be very prominent.

However, several writers have contended that the new format represents a challenge to today's learners for whom narrative traditions of teaching are being supplemented by more open systems for exploring knowledge (Plowman, 1996; Laurillard; 1995; Stafford, 1994). Hypertext, it is argued, allows people to jump from topic to topic almost instantaneously and this has been taken to mean that the order inherent in printed linear text has been abandoned.[6] But, it is argued, that without some form of structure being given to the learner the courseware becomes simply an 'information repository'. Unless there is a strategy for guiding the student in finding and interpreting information the instructional designer is simply creating a 'web' type structure and the onus on developing an information seeking strategy is placed on the student. In this respect research such as that conducted by Ross and Morrison on the manner in which different students

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[6] *It is important not to overstate the case when considering this issue. In fact we could question how much narrative has actually disappeared in most courseware. An examination of multimedia CAL packages shows that a didactic approach which requires linear processing of information is still the predominant means of organising teaching material. Indeed it is extremely difficult to conceive of a piece of courseware in which some form of narrative or story line cannot be traced and even where students are offered a choice of order in which they use parts of courseware it generally the case that the courseware itself is chunked into parts in which there is an identifiable narrative.*

take control of their learning should give cause for concern (Ross and Morrison, 1989). Arguing that learner control is a multi-dimensional construct, Ross and Morrison examined the manner in which high and low ability learners used multimedia systems. They concluded that high ability learners can manipulate instructional as well as presentational aspects of the hypermedia based lessons to their advantage but suggest that lower ability students benefit from the presentational features but not from instructional control. This may also have been a contributing factor in findings reported by studies by Steinberg that learners often failed to make full use of enhanced features (Steinberg, 1989) and also confirms the findings of Gay that low achievers lack the knowledge and motivation to make appropriate decisions about pacing (Gay et al., 1991). Other studies have demonstrated problems with learner confusion over sequencing of content (Stanton, Taylor and Tweedie, 1992) and the amount of practice which they require. Failure of weaker students to take control over their learning is also noted in a study which considers student reaction to feedback and the choices they adopt in terms of pursuing or ignoring 'remedial suggestions' generated by the courseware (van der Linden, 1993).

There is, therefore, considerable debate as to how flexible multimedia systems should be in permitting free exploration. Marchionini and Neuman contrast the open control advocated by authors such as Papert (1980) and Dias and Sousa (1997) which are liberal and unstructured, with the more didactic modes which limit learner choice to certain domains and lead more directly to specific knowledge (Marchionini and Neuman, 1994). The question revolves around how much freedom learners can be given to create their own way through courseware given the view that in some cases learning must be structured sequentially in order to develop arguments or points of view and to develop learners' understanding of complex issues by underpinning the development of these issues with an appreciation of more basic facts and principles.

Obviously, there must be a balance between leading the student and directing the learning by limiting choice, and creating an open structure in which the student is free to explore topics, discover connections and engage in reflective learning. Current thinking suggests strongly that a structured approach is required when authoring course material within a hypermedia environment and the degree to which we balance structured navigation with "anarchic" browsing must be considered carefully with respect to the learning objectives for the courseware. (Dwyer, 1994). But this is not consistent with the discussion above on the cognitive approaches to learning which support the development of open structures in courseware design and contend that as far as possible courseware must support independent flexible learning. Indeed it seems to support the view that the task of instructional software is the *'sequencing of a student through the content material'* (Cohen, 1983) and this view is typically a hallmark of the behaviourist approach to courseware design.

There are thus important questions which need to be investigated about the manner in which students use multimedia CAL and in particular the manner in which they use the course material when they are given control to determine the manner in which they will access and use parts of the material.

As with most issues of pedagogy the problem of how much learner control is best for students working with multimedia CAL resources requires relativistic rather than absolute solutions. Marchionini (1994) suggests that a staged progression of learner control is superior to what he terms the 'cookbook' or the 'sink or swim' approach and concludes that the tension between student directed and teacher directed learning is best managed by ensuring variety of approach.

> *Flexible learning environments may be designed primarily to support self-directed learning but must also provide mechanisms such as the path tool that allow students to follow carefully designed instructional paths (Marchionini, 1994, p.374)*

However, the manner in which such variety is managed is not yet clear.

In part, clarification might be possible by examining in more detail the objectives of particular CAL applications with respect to the type of teaching being delivered. It would be expected that user navigation patterns may change dependent on the type of material being studied. Traditionally, didactic approaches to teaching such as lectures and demonstrations, by their very nature require a set pathway or narrative within the learning material. However, in teaching in which the objective is to develop or inculcate a particular procedural skill or practical ability a different approach is possible. In these cases the approach which is consonant with instructional design based on cognitive principles would be valid and would allow the learner to determine the manner in which he or she develops the skills irrespective of any pre-conception of the 'ideal' way of learning the subject which the tutor may possess. Thus students could be free to decide whether to learn by using worked examples, or learn by hearing or seeing the procedure explained and relating this to the background theory, or even learn by simply attempting the practical procedure (and almost inevitably learning by mistakes).

4.5 Conclusion

The main benefits of interactive multimedia systems are thus claimed to be found in the use of a variety of media and the opportunity which they can provide to allow the learner take more control over their own learning. However, in neither case are these benefits 'proven'. The research which has been conducted in both areas is still inconclusive and in both areas this has prompted significant criticisms of 'pseudoscience' and a failure to provide robust and verifiable conclusions in research studies. (see in particular R.E. Clark's paper on *Confounding in educational research*, 1995, and T.C. Reeves paper on *Pseudoscience in computer-based instruction: The case of learner control research*, 1993). Certainly there are many examples in the literature of very wide ranging assertions based on assumptions about the manner in which learners interact with multimedia systems and it is often difficult to see how they can be justified. A good example of this is provided when one examines Winslow's contention of the manner in which a particular piece of multimedia courseware was used by students when he states that:

> *Students preferred to activate nodes linked to visual representations of information because they perceived that medium as more interesting and more like the way their memory operated ... [and] ... students who activated primarily visual information did so because the medium was commensurate with their perceived learning styles (Winslow, 1996, p.872)*

Notwithstanding this, examining the points outlined above suggest the argument for use of multimedia computer assisted learning still centres largely around the mode of delivery. However, in the cognitivist model the educational intervention has the potential to be much richer. The use of enhanced graphics and in particular the use of animation and video provide the potential for developing sophisticated simulations and of reproducing a more 'authentic' environment on which to base approaches to learning which can be much more open. Whilst there is debate on the extent to which it should be implemented another major difference between this and the behaviourist model presented in Chapter 3 is an acceptance of the fact that the learner can take personal control over use of the teaching material and can work independently toward the achievement of pre-defined learning outcomes. Such learning outcomes can now be enhanced and rather than concentrate on narrow behaviourist objectives these can encompass a range of problem solving skills. Users can be provided with multiple representations of information and multiple perspectives on learning which can encourage a more analytical approach to interacting with the teaching materials. A diagrammatic model of the main features of this approach to CAL development is provided below (Figure 4.3).

Cognitive approaches to the pedagogical design of computer assisted learning packages move away from the objectivist approach derived from behaviourism which assumes that learners are 'empty vessels'. As a consequence the approach to design of such packages moves from an instructivist or transmissionist approach which assumes that the goal of learning is simply to transmit knowledge to the learner. Cognitivism and in particular constructivism assumes that the learner will build on his own knowledge base and existing experiences to construct his or her own knowledge. Thus as Philips contends,

> *'A major goal of the constructivist environment is to ensure that the learning environment is as rich and interactive as possible' (Phillips, 1997).*

However, it has to be acknowledged that in terms of achieving this goal there are significant problems and issues related to design of multimedia courseware and there is a general concern that the heurisitics for constructivist courseware design still appear to be vague, with a number of authors advocating that more work is required on the instructional design principles needed to accomplish these activities.(Jonassen, 1994)

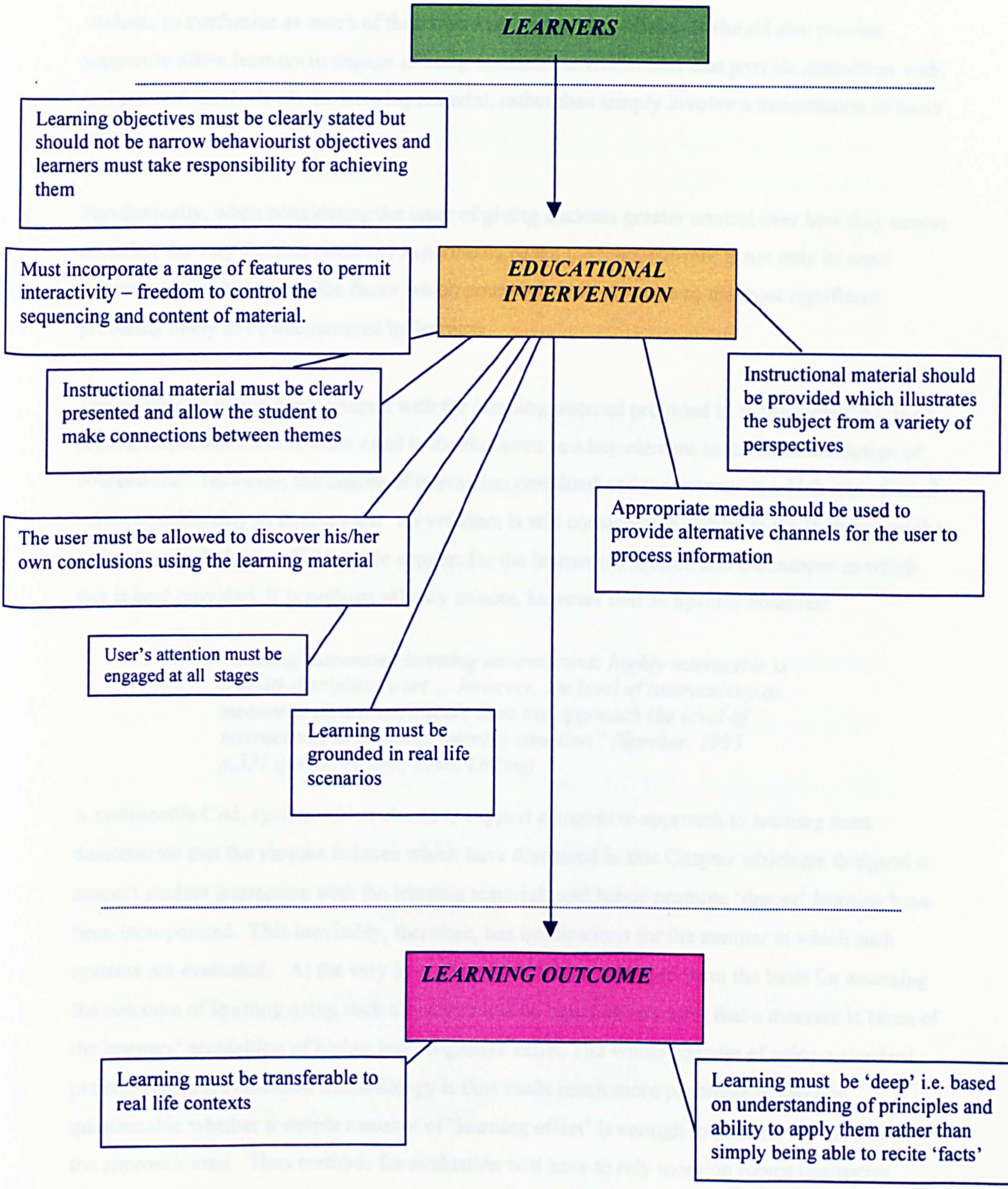

Figure 4.3 ***Model 2 –Cognitivist Model of Computer Assisted Learning System***

Furthermore, there is a significant shift towards acknowledging the importance of context when developing cognitivist environments. Courseware must provide an environment that allows students to synthesize as much of their own knowledge as possible. It should also provide support to allow learners to engage in using authentic environments that provide interaction with, and promote analysis of the learning material, rather than simply involve a transmission of basic facts.

Paradoxically, when considering the issue of giving students greater control over how they access material, the very flexible nature of hypermedia based CAL courseware is not only its most important asset but is also the factor which potentially can give rise to the most significant problems likely to be encountered by learners.

The manner in which users interact with the learning material provided in multimedia CAL is of critical importance and is often cited in the literature as a key element in the effective design of courseware. However, the degree of interaction permitted and the manner in which it is effected varies considerably in courseware. As yet there is still considerable debate in the literature on the extent to which the 'scaffolding' or support for the learner is required and the manner in which this is best provided. It is perhaps salutary to note, however that as Spector observes:

> *"making automated learning environments highly interactive is a multi-disciplinary art ... however, the level of interactivity as measured on anyone's scale does not approach the level of interactivity in a human tutoring situation" (Spector, 1995 p.531 quoted by Sim, 1996, Online)*

A multimedia CAL system which claims to support a cognitive approach to learning must demonstrate that the various features which have discussed in this Chapter which are designed to support student interaction with the learning materials and hence promote 'deeper' learning have been incorporated. This inevitably, therefore, has implications for the manner in which such systems are evaluated.. At the very least the tools which are used to form the basis for assessing the outcome of learning using such a system must be based on ensuring that a measure is taken of the learners' acquisition of higher level cognitive skills. The whole concept of using a standard pre and post test evaluation methodology is thus made much more problematic and it is questionable whether a simple measure of 'learning effect' is enough to confirm the validity of the approach used. Thus methods for evaluation will have to rely more on robust qualitative methodologies which seek to determine student perception of value and utility. These issues are discussed in more detail in Chapter 8.

Finally, one of the most significant differences which is implied by the development of CAL systems which support a cognitive approach to learning is that, as a consequence there is much more emphasis on dealing with the learner as an individual. This involves recognising the importance of individual cognitive processes as an effect factor in determining the outcome of using CAL. These individual differences are discussed in the next chapter.

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Chapter Five

Individual Differences

> *'The practical consequence of the fact of individual differences is that every general law of teaching has to be applied with consideration of the particular person in question.'*

(Thorndike, 1906)

5.0 Objectives

The objectives of this chapter are:

- to review research into a range of factors related to individual learner differences which have a potential impact on student reaction to and use of CAL systems
- to critically examine research related to learning styles
- to relate these factors to developing a model of multimedia CAL systems in order to further an understanding of the basis on which such systems should be evaluated

Almost a century after Thorndike commented upon the importance of individual differences it is obvious that, in many respects, we are still adopting educational approaches that patently disregard it. The value of traditional lectures has long been the subject of debate and Race's finding that sometimes as little as 5% of a lecture's content is retained by students should give grounds for serious concern (Race, 1992). In a practical situation the lecturer is often aware of the fact that the "message" which he wishes to deliver is not being clearly transmitted in that in some instances the material being given is too basic for certain sections of the class and in others too advanced for another section. In the light of this it is important in this respect to note that in the last decade there has been a significant change in the profile of cohorts entering university. (MacFarlane, 1992). Not only are university numbers increasing but initiatives to increase access to higher education and to provide opportunities for a wider range of potential students has meant that it is no longer the case that we can view higher education as a chronological and developmental extension of secondary education. The diversity of the student population in terms of age and experience makes it important to look at how instruction can be made more relevant to individuals. The requirement to be able to interact with students on a personal level could of course be cited as a justification for a system of higher education that relies heavily on a 'personal approach' to teaching and is sometimes advanced as an argument against technological innovation. (Postman, 1992; 1995)

There is no disputing the fact that personal communication is a vital part of education - but the manner in which that communication is handled needs to be considered seriously in order to ensure that it has maximum impact. In particular it is vital to recognise the fact that communication in teaching is not a one way process - the learner's progress must be monitored and tasks have to be set to evaluate and give practice in new knowledge or procedures, related issues must be discussed (often at the prompting of the student) and related to the main points being made in order to give new light on the information or allow its examination from a different perspective.

As discussed in the previous chapter, the strength of the cognitive approach to delivery of teaching is that a central feature of this approach is that the manner in which students think affects learning – instruction influences thinking which in turn affects the performance of students. Thus, as well as stressing the need to provide flexibility or incorporate 'interactivity' in the design of instructional method itself, the cognitive approach views instruction as being mediated by student thought processes and hence factors such as learning style, motivation and other attitudinal influences are all viewed as important elements in the learning outcome. This chapter, therefore, reviews these issues in order to provide a more complete picture of all of the factors that contribute to a model of how multimedia CAL systems function and the variables that need to be controlled when attempting their evaluation. The chapter concentrates particularly on issues related to learning style and this was one of the key learner differences explored in the practical studies investigating student reaction to use of CAL which is described in Part two of the thesis.

5.1 Aptitude-Treatment Interaction

An educational theory that is central in supporting the view that individual differences must be reflected in learning materials is Aptitude-Treatment Interaction (ATI). ATI first became prominent in the late 1960's when Cronbach, a pioneer in the area, published a theoretical paper explaining the rationale for such research (Driscoll, 1994). ATI seeks to identify characteristics of a learner (such as learning styles, motivational levels and attitudes/anxiety levels) and then create instruction that can accommodate the learner's needs (Chan & Cole, 1986). The concept that some instructional strategies (treatments) are more or less effective for particular individuals depending upon their specific abilities is developed in this theoretical framework. ATI suggests that optimal learning results when the instruction is exactly matched to the aptitudes of the learner. According to Snow (1989), the aim of ATI research is to predict educational outcomes from combinations of aptitudes and treatments. In joint work with Cronbach he identifies and summarises the problems of the approach (Cronbach & Snow, 1977) as being that while aptitude treatment interactions are very common in education, many ATI combinations are complex and difficult to demonstrate clearly[1]. Indeed the authors also contended that no particular ATI effect was sufficiently understood to be the basis for instructional practice. To an extent this work can be seen to be the foundation for much of the later research on individual differences and their potential impact on learning in the context of developing appropriate instructional materials. Early ATI research covered a broad range of aptitudes and instructional variables; it has been used to explore new teaching strategies and curriculum design, especially in mathematics and reading. This work led the authors to conclude that the best supported ATI effect involves treatments that differ in the structure and completeness of instruction and high or low "general" ability measures. Highly structured treatments (e.g., high level of external control, well-defined sequences/components) seem to help students with low ability but hinder those with high abilities (relative to low structure treatments). (Driscoll, 1994; Snow, 1989)

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[1] *It should also be noted that Snow identifies the lack of attention to the social aspects of learning as a serious deficiency of ATI research and this re-inforces the view that an holistic approach is required to examining the various factors related to individual differences in order to be able to make meaningful observations about the significance of individual learner variables when evaluating learning outcomes. This, however, is rarely the approach adopted in research which seeks to explore 'learning effects' and CAL.*

Thus it is contended that aptitudes and instructional treatments interact in complex patterns and are influenced by task and situation variables. In particular, highly structured instructional environments tend to be most successful with students of lower ability; conversely, low structure environments may result in better learning for high ability students. Furthermore, anxious or conforming students tend to learn better in highly structured instructional environments; non-anxious or independent students tend to prefer low structure.

Succinctly defined, therefore, ATI is the attempt to evaluate individual student differences (aptitudes) and subsequently develop specific instructional strategies (treatments) to accommodate these differences (Driscoll, 1994). Such a view clearly indicates a need for educational research to concentrate much more effort into understanding the manner in which students themselves view their own educational experience and the ways in which they engage in learning. These concerns have been evident in the literature published on CAL over the past two decades and CAL systems themselves have been represented as useful tools for studying the basis on which learners interact with learning material. However, some authors have been sceptical about the value of the claims made for CAL as the basis for providing 'individualised learning environments'. As Carrier noted:

> *The only major principle that has consistently guided attempts to individualise instruction or to accommodate differences is that learners should be allowed to work at their own pace. (Carrier, 1984, p.17).*

This principle still remains as one of the most cited advantages of using CAL although now, because of the advances in telematics and distance learning it is often amplified to include place as well as pace. More recently the dominant argument in the literature has concerned the ability of CAL courseware to provide the potential for learners to tailor their access to and use of the learning materials to fit in readily with their own preferences for learning, in a sequence which suits them and which allows them to engage in deeper learner by taking more personal control in the construction of their learning. This is the most common claim made as the one essential feature of multimedia based computer assisted learning related to its ability to individualise instruction (Ramussen and Davidson, 1996, Ross, 1997). However, as was noted in the previous chapter, workers in the field of human computer interaction have drawn attention to several problems related to the general design of CAL interfaces – in particular a great deal of work has been done on the problems of information overload and navigational difficulties. In addition to these design issues a number of writers have questioned whether all students are served equally well by computer assisted learning materials in terms of the students themselves being equipped with the necessary skills and motivation to use these systems effectively. (Butler, 1984; Nelson and Palumbo, 1992; Stanton, Taylor and Tweedie; 1992, Ross, 1997) As the use of CAL systems has grown there has also been a growing concern that certain human factors related to interaction with such systems are not clearly understood. This is evident in a number of studies that have examined learner characteristics such as prior domain knowledge, level of confidence with technology, gender, age, motivation and learning styles. Moreover, after decades of research in the area, it remains unclear as to what types of instructional methods are best for certain types of students. The following sections review issues related to factors which influence individual use of CAL and in particular the discussion concentrates on the question of learning styles and degree of computer confidence. These are areas which in the literature have been most commonly described as potential causal factors for explaining the attidude to and performance achieved by learners using CAL packages. Thus these will also be the main factor which will be investigated in the empirical work undertaken in this programme of research.

5.2 Individual Learner Differences

5.2.1 Motivation

One of the most important features to consider in terms of individual differences in learners is the motivation that drives students to learn. Race provides a model of learning in which the first, and arguably the most important, stage is that the student must **want** to learn. Affective considerations in any activity are vital to its success and will obviously impinge on the evaluation of the activity. Motivation may be considered as either intrinsic (where the student is motivated because of a wish to increase his/her knowledge or understanding, through curiosity about the subject or interest engendered as part of the activity itself) or extrinsic (where a specific external goal or reward is the prime factor in determining the desire to perform well). It is one of the most important but also one of the most difficult features to achieve in developing educational materials. (Entwistle, 1984). Motivation gives direction to behaviour and it is contended that motivators such as challenge, fantasy and curiosity (Malone, 1984) enhance learning by encouraging students to spend more time on studying and relating what is studied to their own particular experience. (Stoney and Oliver, 1997; 1998). However, as Lepper points out we know surprisingly little about the fundamental question of how motivation affects learning. (Lepper, 1985).

Motivation can thus be considered as a learner variable or as an instruction variable and as such we need to consider both of these aspects in which it is a factor which impacts on the evaluation of CAL instruction. As an instructional variable there is considerable interest in the manner in which multimedia CAL delivery can itself enhance the motivation of students who use it.

Because of the fact that CAL materials are often designed to be used independently in order to be successful a CAL package must maintain the interest and motivation of students and engender a desire to learn. Whilst it is commonly stated in the literature that developers must create intrinsically motivating software there is no real agreement on how this should be accomplished. Some studies have focussed on the benefits of presenting content using technology and the positive advantages to be gained by using a novel interface. In a number of early studies on the use of CAL there is an assumption that the use of computers positively affect motivation and this in itself was seen to be a positive factor which should increase student motivation. However, such studies failed to fully explore this issue in detail and generally examine it in the context of overall reaction to CAL rather than providing an analysis of individual learners (Schlechter, 1991). In recent studies whilst the assumption that use of the computer in itself is sufficiently novel to engender motivation is discarded [2] there is still a great deal of attention paid to novel features of the interface such as animation and video as motivating factors. (Baudel, 1993; Bell, 1997)

It is not enough to assume that computers themselves are motivating and thus a number of studies have sought to provide guidelines or exemplars to identify key motivating factors and to demonstrate how courseware can be improved with respect to incorporation of features designed to encourage motivation. The interest by adolescents in arcade games and other microcomputer

[2] *This may be explained by the fact that as the use of computers became more prevalent in both higher education and in personal settings thus the reported advantages associated with the novelty of the delivery mechanism have declined.*

based software has often been seen as a model for the incorporation of motivating factors into educational software. It is difficult, however, to see how the main features of such software, i.e. the ability to engage attention through fantasies based on emotional factors which involve the user in interacting with the system at a personal level, can be incorporated in software designed for use in higher education. As Draper notes:

> *Inherent in the notion of fun is that it seems to be that it doesn't matter what the product of the direct result of the action is: something is fun to do not done as a means to an end, i.e. it is an activity done for its own sake, the sake of the process (Draper, 2000, Online)*

Viewed in this light it could be argued that simply incorporating elements of 'fun' into courseware does not in fact contribute directly to learning since learning must be directed towards the achievement of goals as part of the process. We must, however, be careful to distinguish this from the idea of 'play' being incorporated into learning environments. Play is a performing process in which an important component is discovering what the outcome of performing the process will be and this inevitably leads to learning. It has thus been argued by some that building on the play or a version of it should be an inherent part of a multimedia program and there are interesting examples of this in some recent multimedia CAL programmes which have been designed as constructivist learning environments. (Herrington, 1999; Stoney, 1998). The underlying assumption is that if we can combine the play aspects within an educational framework improved learning outcomes should follow (Stoney, 1998). A summary of mechanisms to achieve a variety of desired learner effects for increased motivation is provided by Stoney. (Stoney, 1998) However, building such an environment is extremely expensive and time consuming and most multimedia CAL packages lack the level of sophistication which role playing or games software designers require.

In terms of more 'conventional' learning courseware Keller and Suzuki (1988) offer some insight into the problem of motivation. Their ARCS Model of Motivational Design identifies four factors that influence motivation to learn:

- Attention
- Relevance of instruction to individual needs
- Confidence for achieving learning success

- Satisfaction with the learning experience.

If any one of these identified areas is deficient or not present, students' motivational levels can falter. White's seminal work on motivation concentrates on the intrinsic need of students to build up confidence within a learning environment and contends that behaviours that satisfy confidence are self-rewarding (White, 1959). This clearly indicates that self-assessment elements in multimedia courseware are of critical importance in achieving motivation and the goals of such assessment and the manner in which feedback is given must be carefully considered to ensure that confidence is both established and consolidated. A common theme in the literature is the use of multimedia to assist in creating environments which hold student attention. The manner in which the courseware is packaged and presented is extremely important, so much so that some commentators argue that the interface itself is the most important part of multimedia.

It has already been noted in Chapter Three that a seemingly trivial reason for students finding multimedia CAL interesting is the use of a variety of media. In terms of designing courseware which enhances student motivation to learn this should not be seen as insignificant - the end user often perceives the application as 'better' because the addition of non text media enhances the quality of the presentation. There is a wide range of literature on design for multimedia (Boyle, 1997) which draws from a range of disciplines – information processing, psychology of perception, human computer interaction and presentation design and aesthetics. However there is still no clear indication of the impact of interfaces on factors such as motivation. Small and Grabowski (1992) attempted to tackle the question of how user motivation affects movement through CAL programs, attitudes towards CAL, and learning outcomes, but the results of their work has been inconclusive and they simply state that much more data is required in this area. This is understandable, perhaps, given the rate of change in the capacity of hardware and software to present a variety of stimuli and incorporate a range of media techniques. What is clear, however, from many affective studies is that the effect of interface design is obviously very important in terms of fostering or developing intrinsic motivation to learn.

The other area to be considered is extrinsic motivation. Draper laments that the most common reason for failure in attempts to introduce innovative approaches using CAL is that "No one used it!" (Draper et al., 1994). This is almost always because CAL has been introduced to the students as being 'optional' or 'additional' and to a large number of students this equates with 'superfluous'. Students need to have a compelling reason to make use of the courseware. (http://darkwing/uoregon.edu/~tep/artt; 1999). It is important not to be tempted to over-generalise this point. Some authors have asserted that motivation and incentives to learn are dependent to a large degree of self-initiation of learning (Gugliemino, 1989) and this may in certain circumstances moderate behaviour which is mainly directed at achieving required grades or gaining knowledge which is specifically directed towards the goal of passing examinations. Nonetheless, it has to be acknowledged that one of the most compelling reasons to use the courseware is assessment and it has been established that - given the increasing tendency for students in higher education to be 'assessment driven' - the manner in which students react to using courseware is dramatically affected by whether or not they perceive that the outcome of their use of the courseware will be directly assessed (Newton et al., 1998; Draper et al, 1994). The implications of this for evaluation of multimedia CAL software are very significant. If we assume as stated above, that motivation has a large impact on the achievement of learning outcomes then the environment in which the courseware is used and the conditions under which students are required to work with the courseware will be of critical importance when evaluating the success of the courseware as it is directly relevant to forming learners opinions of the value of the courseware. As Draper et al. note:

> *It is clear to us that motivation to make some effort is a much bigger factor than quality of the material, and indeed is essential. Furthermore, this motivation is not a personality characteristic but is externally controlled by those running the course, modified by student perceptions of its impact on their results. (Draper, 1994, p.11)*

Unfortunately, in the bulk of the published studies on CAL the exact conditions under which the instructional material has been used is not made clear. Thus an important factor affecting the outcome of such studies is not considered.

5.2.2 Level of confidence with computer systems

When dealing with teaching environments which are based on the use of technology it is always important to bear in mind the complications which are introduced by using computers as the basis for delivery. Whilst it is increasingly the case that learners can be expected to be fairly familiar with the basic use of technology it is quite wrong to assume that all learners are equally competent or comfortable in doing so.

This is an issue which is often linked to motivation as it is generally held that the motivation or effort students invest in using computer based learning materials is a function of how easy they think it is to learn using this medium. Beliefs in computer learning being difficult or irrelevant will therefore have a profound impact on outcomes. As with motivation we can consider that the approach of the learner to using a computer based environment is dependent on beliefs and attitudes which are learner variables not instructional variables. Just as we can try to enhance motivation to use packages through attractive interfaces it is important also to tackle the issue of if CAL is perceived as being more difficult. (Saloman, 1983). Marcoulides confirmed reported findings from Lloyd and Gressard suggesting that as many as one-quarter of students have anxiety towards computers and related computer technology (Marcoulides, 1988). In her own study, Marcoulides found that the higher the level of computer anxiety, the lower the achievement levels observed in her sample of university students. This is confirmed by more recent research. Liu and Reed (1995) conducted a study investigating the effects of individual differences on human-computer interaction. Subjects were given the GEFT (Group Embedded Figures Test)[3] to determine learning styles as well as a survey to determine computer anxiety and computer attitudes. The data revealed that achievement levels were negatively correlated with anxiety levels; that is, participants who had higher levels of anxiety performed poorer than did those who had lower levels of computer anxiety. Liu and Reed concluded that

> *'Learner performance has much to do with (students') degree of computer anxiety, their attitudes towards computers...and their learning styles" (Liu and Reed, 1995, p. 162).*

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[3] *This is discussed in more detail in Section 5.3 which examines the issue of learning styles.*

Gaston and Arndt conducted a study which suggested strongly that a major influencing factor on attitude was prior experience with CAL (Gaston and Arndt, 1991)and their work seemed to confirm Neil's earlier contention that this effect is particularly marked if a student has had a negative experience with a poorly designed CAL program. (Neil, 1985). The results from the study conducted by Gaston and Arndt (1991) are consistent with findings from a study published by Brudenell and Carpenter (Brudnell and Carpenter, 1990). The researchers measured the attitude towards use of CAL in a survey of 40 students using a tool which they developed and refer to as the Attitude Toward CAI Semantic Differential Tool. The Kolb Learning Styles Inventory (Kolb, 1985) was used to group subjects according to learning style. The researchers discovered that experience with computers significantly affected attitudes towards CAL, much more so than did cognitive learning styles.

James and Gardner thus warn that it is futile and potentially harmful to use technology alone without considering individual differences and in particular without examining attitudes towards technology (James and Gardner, 1995).

5.2.3 Domain knowledge/Level of prior knowledge

Current research on the use of CAL environments has also been concerned with a consideration of entry level familiarity with content. Domain knowledge refers to the realm of knowledge an individual has about a field of study, (Alexander, 1992) and is obviously a significant factor which will affect the way in which an individual performs during a learning intervention. Prior domain knowledge is also a significant factor when considering how the user will react to processing information and the manner in which the learner perceives the worth of the instructional material. (Entwistle, 1982; Brosnan, 1998). One of the most pervasive themes to merge from literature which explores the issue of prior domain knowledge is the expert/novice dichotomy and several studies have shown significant differences in approach to problem solving and learning which are exhibited by both types of user. (Chi, Feltovich & Glasser, 1981; Bereiter & Scardamalia, 1986; Hannisch, Kramer, & Hulin, 1991). In terms of conducting evaluation of CAL it is important to recognise that level of domain knowledge is an important learner variable. It is further important to recognise the full significance of prior domain knowledge in relation to studies which attempt to use pre and post testing as a means of establishing a 'learning effect'. In many studies of CAL which use an overall learning effect as a means of measuring success of the courseware there is an acknowledgement there may be a considerable variation in learners' starting knowledge and moreover that this will have an impact on the manner in which the learner effectively interacts with the learning material. Thus, for example a student who is a complete novice may achieve a lesser 'gain' because of unfamiliarity with how to extract and contextualise information from the courseware. Similarly a learner who is an expert on the subject being studied may achieve no additional 'benefit' as indicated by pre and post test scores. However, in providing a simple scalar measure of learning effect for all subjects these issues are effectively ignored. Thus in evaluating CAL we need to be much more careful to isolate the impact of this variable on learning outcomes. Knowledge acquisition cannot be tested without a detailed consideration of the more difficult issue of its re-structuring.

5.2.4 Gender and Age

Whilst a number of studies cite gender as a potential factor which needs to be considered when designing online learning environments, there is no conclusive evidence that this is a factor which in itself is of critical importance. A seminal article by Malone identified gender as a significant factor in learner attitude towards use of a computer based learning package (Malone (1984); however, a more recent study using updated versions of the software used by Malone found no effect. (Abercrombie and King, 1996). Chou, however, concludes that there is a significant link. (Chou, 1996). In an evaluation of a hypermedia Music CAL system Chou reports that males benefited more from the CAL system than females. Likewise, Kern notes an effect (though not significant) and Toh, although not presenting empirical evidence, asserts that gender differences are a contributing factor in students' performance (Kern, 1988; Toh, 1996). These, however, appear to be matched by a number of reports which show no significant effect. In reported use of a CAL package to support teaching of statistics Giesbrecht, Pyryt and Sandals report that participants age and gender appeared unrelated to their performance (Giesbrecht et al, 1997). King reports no significant effect on anxiety or outcomes using web based course delivery which can be correlated with gender. (King, Henderson and Putt, 1997).

It is not easy to determine from the studies which have been examined and are referred to above, whether there is a pattern which could account for the discrepancy in findings. Certainly there appears to be considerable evidence about differences between young children's attitudes to computers (Huff and Cooper, 1987; Hall and Cooper, 1991; Inkpen, 1997) but not easy to see how this effect is apparent in higher education. It may also be the case that factors in the software which is being used (e.g. problem based scenarios, use of case studies) are specifically biased towards either males or females. It is thus important to examine this factor when designing studies. This is particularly important in terms of conducting evaluations which investigate learning style. Recent work which examines cognitive style and performance when using environments in which the material was either matched or mismatched with learners cognitive styles found significant effects in gender (Ford and Chen, 2001). It was determined that this was an aspect which should be further pursued in the empirical studies forming part of the research.

Similarly when examining the issue of age and performance and attitudes to computer assisted learning it is obvious that age may be a factor which is influenced and influences other variables. Thus, for example, Knowles' theories, which attempt to develop a theory specifically for adult learning, emphasize that adults are self-directed and expect to take responsibility for decisions. (Knowles, 1984a). Knowles has identified a number of characteristics of adult learners (e.g. their need to know why they need to learn something, need to learn experientially, preference for learning as problem-solving) which differentiate them from other students and which he argues have to be accommodated when teaching. (Knowles, 1984b). Thus it is important also to view level of maturity as a factor which may influence results of any evaluation of use of CAL materials in particular with respect to the fact that there appears to be evidence that level of maturity affects learning style, Curtis and Winsor contending that "the adult learner generally is more culturally diverse and often presents a diversity of learning styles" (Curtis and Winsor, 1993)

A range of other factors which are related to performance have been identified including degree of personal involvement and self direction (Gugliemio, 1989; Hilgard, 1975), personal conception of the study environment, materials provided, tasks set and pressures in achieving deadlines (Saljo, 1979; Entwistle, 1982), intelligence and anxiety (Brooks et al., 1985; Cronbach, 1977; Fransson, 1977), and personality (Leith, 1969; Robertson, 1977). Some of these variables are related closely to context in which learning takes place and may be controlled to an extent by carefully controlling the environment in which CAL is introduced and used by learners. Others are factors that can only be accommodated in studies by adopting close observational strategies and detailed learner profiling.

5.3 Learning Styles

Information is perceived and processed in various ways according to an individual's perceptual and sensory strengths. This combination of perceiving and processing forms the basis for the construct of unique learning styles. However, it would be wrong to take the view adopted by some authors (e.g. Mills, 1999) that learning styles are simply a function of perception. Many of the mechanisms by which people learn are still unknown but obviously very complex physiological, psychological and social processes are at work and learning styles research draws on all of these. A learning style is a way in which a learner begins to concentrate on, process, and retain new and difficult information (Dunn & Dunn, 1987). Learning involves a procedure of assimilation to understand new knowledge and accommodate it in mental constructs based on prior learning. (Whalley, 1990). This is quite distinct from simple memorizing of facts or aggregation of discrete pieces of knowledge and it is contended that in undertaking this very complex process learners exhibit certain styles which reflect a preferred way of thinking (Entwistle, 1981). This fundamentally affects their predisposition to adopt a particular type of learning behaviour. (Schmeck, 1985). The aim of learning style research is to identify a useful method of clustering people who use similar patterns for dealing with how they structure their learning to interpret and assimilate new knowledge effectively.

Draper notes a need for caution in defining terms in this area. He asserts that there are different kinds of thing, any of which might conceivably be called "style", but all of which we should consider as they are all learner 'properties' that potentially affect learning outcomes in different ways (Draper, 2000).

The list which he provides and the distinctions which he makes are summarised in the Table 5.1 below.

Table 5.1 Learning Styles, Cognitive Styles and Traits (adapted from Draper Learning Styles (Notes), 2000 http://www.psy.gla.ac.uk/*)*

Term	*Interpretation*
Learning Styles	Strategies or regular mental behaviours which are habitually applied to learning – particularly deliberate education learning, and build on his/her underlying potential e.g. holistic/serial (Pask)
Cognitive Styles	Strategies or regular mental behaviours habitually applied by an individual to problem solving (e.g. divergent/convergent thinking)
Traits	Persistent potential abilities which vary from individual to individual e.g. IQ, field dependence/field independence[4]
Prior vocabulary	Familiarity with common key words without which an individual experiences barriers to learning
Prior knowledge	Prerequisite concepts required for learning

The last two terms effectively deal with prior knowledge and have been discussed above. The first two terms are often used interchangeably and it could be argued that the distinction between problem solving skills and mental or cognitive approaches to learning is so fine as to warrant a consideration of learning styles and cognitive styles as almost synonymous concepts (indeed in Draper's paper the terms are used interchangeably)[5]. The distinction between these and traits, however, is an important one and other authors have also been at pains to point out that learning styles are clearly distinct from personality traits or intelligence (Bottenberg, 1966; Schroder, 1971).

The term adopted in this research will be learning style and it will be used as defined by Draper in Table 5.1 to mean 'regular mental behaviours, habitually applied by an individual to learning, particularly deliberate educational learning' (Draper, 2000). There is, within this definition, still considerable scope for interpretation of what constitutes a learning style. Learning style is often defined in terms of conditions, content modes, expectations, stimuli, distinctive behaviours, dualities, conceptual level, past experience, environment, deep and shallow information

4 Note that whilst Draper views this as a trait a number of authors clearly identify the question of field dependence or field independence as being indicative of a particular learning style as is evident in many research papers on the topic

processing, field dependence/independence, and other characteristic patterns of processing information that appear to have notable differences. There are also cautions against an overemphasis of learning style differences which may lead to a new form of inaccurate labeling and stereotyping. Not only are there striking differences in the way people learn and process information, but there are significant differences in how learning styles are defined and measured. A number of authors have identified a range of features which are variously referred to as learning styles or cognitive styles or traits. Thus when examining the literature a large number of different models of learning styles have been proposed and have been discussed. (Messick, 1970; Entwistle, 1982, Ford and Ford, 1992).

The reason for the confusion is perhaps understandable. To identify a person's learning style pattern, it is necessary to examine the individual's multidimensional characteristics. Because of this there are a number of different measures of learning style dependent on which of the factors are emphasised. Factors which are normally tested in order to make up learning style are:

- the three senses - auditory, visual and kinesthetics;
- the two reasoning types - deductive and inductive;
- the two environments - intrapersonal and interpersonal.

These are used as the basis of characterising learners as e.g. serialists or holists (Pask, 1976), analytic or synthetic learners (Vernon, 1962), scanner or focusers, (Beard and Hartley, 1984) abstract or concrete (Kolb, 1985 Gregorc, 1982b). The result is that there is considerable confusion when reading the literature over the question of exactly what distinction authors are making when they refer to learning style.

As with the discussion of learner control in Chapter 4 it is useful to find some form of classification of learning styles in order to clarify the manner in which the term has been used define the parameters within which learning style has been defined in the current research.

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[5] Draper's discussion on this topic appears to confuse an important distinction between learning styles and learning strategies. This is discussed further below

Curry's taxonomy is a useful starting point for doing this (Curry, 1987). Basically Curry identified a number of layers (categorized and characterized as different layers of an onion. See Fig 5.2).

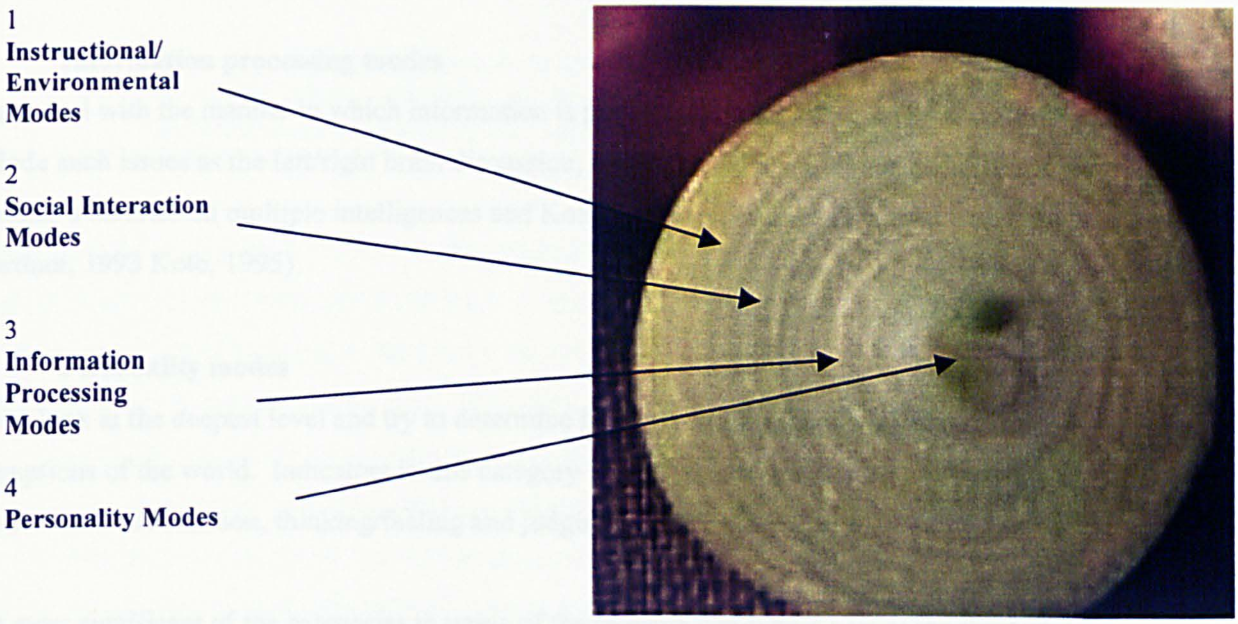

Fig 5.2 Onion Layer model of learning styles.

These layers depict features of learning styles based upon:

1. Instructional and environmental preferences

These deal with observable traits such as environmental considerations or preference for type of learning situations and specific types of learning task.

Dunn and Dunn further categorise these into 5 elements:

1. Environmental preferences regarding sound, light, temperature, & class design;
2. Emotional preferences addressing motivation, persistence, responsibility & structure;
3. Sociological preferences for private, pair, peer, team, adult or varied learning relations;
4. Psychological preference related to perception, intake, time, & mobility; and
5. Psychological preferences based on analytic mode, hemisphericity, and action. (Dunn and Dunn, 1987)

2. Social interaction modes

These deal with actions in specific social contexts and characteristics exhibited by the learner and cover areas such as gender and maturity and social context in which the learner operates

3. Information processing modes

These deal with the manner in which information is processed, stored and used by learners and include such issues as the left/right brain discussion, issues related to serial versus holistic styles, Gardner's theories on multiple intelligences and Kolb's approaches to experiential learning. (Gardner, 1993 Kolb, 1995)

4. Personality modes

These look at the deepest level and try to determine how personality shapes orientations and perceptions of the world. Indicators in this category try to demonstrate differences in terms of extroversion/introversion, thinking/feeling and judging/evaluating.

The most significant of the categories in terms of the research conducted here is the third of these – the information processing mode. This is because the factors related to learning styles derived from information processing model approaches to learner characteristics can be seen to have significant parallels with the cognitive principles which relate to learner control and interactivity in learning environments. This is the area in which particular claims have been made for multimedia CAL teaching packages in terms of their ability to accommodate a degree of flexibility in allowing learners to process information.

Another important distinction which must be drawn when considering terminology is to distinguish clearly between learning styles and learning strategies. According to Sternberg:

> *A style is a preferred way of using one's abilities. It is not in itself an ability but rather a preference (Sternberg, 1994, p.36).*

This is consistent with Messick's view which sees learning styles as:

> *Information processing habits representing the learner's typical mode of perceiving, thinking, problem solving, and remembering (Messick, 1970, p.20).*

This being the case it would be reasonable to assume that learning style is something which can be adapted or modified by the learner in response to the particular learning environment in which he/she is working. Indeed Snow states that:

> *Learning style differences can be linked to relatively stable person or aptitude variables, but they also vary within individuals as a function of task and situation variables. (Snow, 1989 p.216)*

However, other studies have shown that the construct of learning style is a relatively stable function of how an individual prefers to learn. (Davidson, Savenye and Orr, 1992). In longitudinal studies of learning styles it has been found that learning styles of university students remained relatively stable. (Busato et al., 1998; Geiger and Pinto, 1991). Whilst learning styles are 'a general habitual mode of processing information' (Allinson, 1992) learning strategies are the actual approach taken in a given situation (Nisbet and Shucksmith, 1986). It seems reasonable to assume that a new type of learning environment may force a student to adopt a learning strategy which is at odds with his natural learning style. It would also appear reasonable that in such situations the learner may not be comfortable with this environment for learning and that such a situation could have a detrimental impact on learning.

Thus a number of authors have hypothesised that if a student's learning style corresponds with a particular instructional strategy this improves the student's ability to concentrate and learn. This indeed has become a fundamental assumption which underpins the value of research into learning styles and various studies have in fact verified that students learn best when they can address knowledge construction and assimilation in ways which they have found effective in the past i.e. there are significant benefits to be gained by matching teaching methods to particular learning styles. (Leith, 1969; Rowoll and Renner, 1975; Domino, 1971)). The most significant demonstration of this was provided by Pask (Pask, 1976). As Draper notes:

> *to show that you have an effect that isn't just differences in general learning ability or general quality differences in the material, you need an experiment that shows a crossover: where type A learners do well on material X but poorly on material Y, while at the same time type B learners do poorly with material X but well with material Y (Draper, 2000).*

Draper goes on to note that Pask demonstrated such an effect. This supports the contention made by Gregorc and Ward that:

> The instructional materials and techniques used by teachers have a direct effect on many students...If the approach fitted the preferred learning mode, the learner usually reacted favorably. If, on the other hand, the methods were mismatched, the student "worked hard to learn", "learned some and missed some material", or "tuned out." *(Gregorc and Ward, 1977 p. 5)*

Thus 'matching', a term Gregorc (1982a, 1982b, 1985) uses to describe learning environments which are consistent with a student's particular learning style, may be necessary in order for students to attain desired learning goals. Some degree of style flexing is desirable, as learners need to develop proficiency adapting to a variety of forms of instruction (Butler, 1984). However, it is also contended that style flexing over a long period of time may have deleterious effects on learners (Gregorc, 1985).

If mismatching occurs, students feel anxious and even physically ill when trying to learn. Sternberg, moreover, observes the obvious corollary that most teachers are best at teaching learners who match their own styles of thinking and learning. (Sternberg, 1994) reporting that students tend to receive higher grades when their styles are the same as those of their teachers.[6] Thus for teachers to be successful, Sternberg believes they must systematically vary teaching and assessment methods to reach all the different thinking and learning styles of the students. Again this is particularly important in a higher education environment where differences in the student population are more marked.

The logical corollary to these findings is that teachers must learn to be flexible and exhibit different styles in their classroom in order to be sensitive to variations in learning style. However, it also seems probable that teachers have a predisposition towards a certain teaching style and thus matching of teaching and learning strategies as advocated by researchers such as Pask may not be easy to achieve (Pask, 1976). Although the idea of matching instruction to students'

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[6] *It should be noted that Entwistle reports a finding that students like to be taught by teachers who exhibit the same cognitive style as they adopt. It is interesting to note that this may attributable to the same phenomenon as reported by Sternberg from the instructor's viewpoint.*

learning styles has been supported in the literature (e.g., Butler, 1984; Hettiger, 1988), it can be difficult for educators to match teaching and learning styles in the traditional teaching environments. This then is the potential strength of multimedia CAL. It is assumed that hypermedia systems can accommodate a variety of learning strategies. However, it would appear from recent research that unless carefully monitored at the design stage development of multimedia CAL can in fact produce learning packages which simply reinforce an individual teacher's preferred learning style. (Fitzgerald, 1997)

5.4 Learning Style Instruments

5.4.1 Kolb

Kolb's theory of learning and identification of learning styles was the origin of most of the subsequent work in this field. Kolb's theory was based explicitly on a view of learning as a series of experiences with cognitive additions rather than as a series of pure cognitive processes (Kolb, 1982). He saw learning as a circular process in which Concrete Experience is followed by Reflection and Observation. This in turn leads to the formulation of Abstract Concepts and Generalization, the implications of which are tested in new situations through Active Experimentation. While his theory described an integrated process in which all stages have to be completed, he moved on to say that people were rarely fully effective in all stages. He produced variants of his main stages and by combining different parts of the four stages, identified four main styles of learner which he labeled as Converger, Diverger, Assimilator, and Accommodator. He developed his Learning Style Inventory (LSI) to establish an individual's relative emphasis on each of the four styles. The Kolb LSI is based on individual's responses to thirty six words. The vast majority of items are behavioural, i.e., they describe an action that someone might or might not be seen to take. Occasionally an item probes a preference or belief rather than a manifest behavior. Their intention is to discover general trends or tendencies running through a person's behaviour.

5.4.2 Other Learning Style Instruments

Kolb's LSI is only one of a number of different instruments which claim to measure learning style. Generally these tests rely on a range of questions or statements about which people are asked to indicate whether, on balance, they agree or disagree. Different learning styles inventories concentrate on different factors and some emphasize one more than another. A summary of some of the more common instruments for measuring learning styles is provided in Table 5.2. A useful source providing a brief guide to the more common learning style instruments is provided by DeBello who compares eleven of the major learning style models. (DeBello, 1990).

As can be seen from the Table 5.2 there are a variety of tests which have been compiled to deal with specific types of students or stages of learning. These tests are now established and have been used extensively in experiments to examine how different learners interact with educational material. Robust tests of various learning style instruments have been conducted to check their reliability. Loo, for example, has produced a very detailed factor analysis of the Kolb Learning Style Inventory (Loo 1999). Fung, Ho and Kwan have examined the reliability and predictive values of Honey and Mumford's Learning Styles Questionnaire (Fung, Ho and Kwan, 1993) and Busato and others have conducted a detailed study of Vermunt's Inventory of Learning Styles – an elaboration of the theories of Kolb, Entwistle, Biggs and others. (Busato et al., 1998). The purpose of the next section is to describe in some detail the Learning Style Delineator developed by Antony Gregorc as this was the test used in the empirical studies as part of this research.

Table 5.2 Learning Style Instruments

Instrument	*Brief Description*
Dunn and Dunn: Learning Style Instrument	A multidimensional instrument covering environmental, emotional, sociological, physical and psychological elements. The LSI provides 100 items and requires approximately 30 minutes to administer. Aimed specifically at secondary school level. (Dunn, Dunn and Price, 1985)
Reading Style Inventory	Developed by Marie Carbo this applies the Dunn and Dunn Concept of learning style to reading
PEPS: Productivity Environmental Preference Survey	A version of the Dunn and Dunn LSI intended for adults. (Dunn, Dunn & Price, 1982)
NASSP: Learning Style Profile	A 42 page, 126 item assessment which was intended for use with secondary school pupils. Extends Dunn and Dunn LSI (Keefe,1989)
Honey and Mumford's Learning Styles Questionnaire.	Developed from Kolb's Learning Style Inventory and follows basically the same procedure.
Group Embedded Figures Test (GEFT)	The Group Embedded Figure Test emphasises distinction between field dependence (focussing on social activities) and field independence (preference for solitary activities) (Witkin and Goodenough, 1981)
Barsch Learning Style Inventory	Based on a classification of learners as exhibiting auditory, visual or tactual (sic) preferences. (Online http://www.hcc.hawaii.edu/intranet/committees)
Myer's Briggs	Based mainly on theories related to personality and although often used as a learning style indicator it is more correctly a personality indicator. The model is based on Carl Jung's theory of personality types. (Myers, 1978)
McCarthy 4MAT	Drawn from Kolb's construct that all people sense and feel, observe and think and experiment and act. Provides four learning style clusters but uniquely contends that all students should receive the same instruction and be encouraged to develop their learning styles to become proficient in using all styles (McCarthy, 1985;1987)
Gregorc	Discussed in detail below

5.4.3 The Gregorc *Learning* Style Delineator

This tool was selected for use in the empirical studies conducted to support the research presented here because of the extensive research conducted by Gregorc on children, adolescents, and adults in various learning environments. It is a simple to use inventory. The test provides good discrimination between learning styles and is easily administered. The Gregorc Style Delineator is a self-scoring battery based on Mediation Ability theory which states that the human mind has channels through which it receives and expresses information most efficiently and effectively (Gregorc, 1982b). According to Gregorc (1982b), the term 'mediation abilities' describes a person's capacity to use these channels.

The Style Delineator focuses on two types of mediation abilities in individuals: perception (the means through which one is able to grasp information), which is viewed as either concrete or abstract, and ordering (the means in which one arranges, systemizes and uses information) and which can be categorised as sequential or random.

Abstractness allows the individual to comprehend that which is not visible to the senses. Data can be mentally visualized, grasped, and conceived through the faculty of reason. This quality is associated with the use of intuition and use of imagination to look beyond facts or situations to find more subtle meaning.

Concreteness refers to the use of the physical senses to comprehend and mentally register data. Concreteness thus implies using abilities to deal with the concrete and obvious and this quality is not associated with looking for hidden meaning or making relationships between ideas and concepts.

Sequential individuals perceive and organize data in a linear, methodical fashion, and can express themselves in a precise manner. Such qualities are often associated with individuals who prefer to have a plan and follow it rather than relying on impulse.

Randomness refers to a disposition to organize and process information in a nonlinear and multidimensional fashion. This quality enables individuals to deal with, and process, multiple data simultaneously. This quality can manifest itself in a learner's approach to use of material where opportunities to start at a random point or process material in an order other than that in which it is presented are often taken.

Gregorc combines these abilities to create four mediation channels of mind styles: concrete sequential (CS), concrete random (CR), abstract sequential (AS) and abstract random (AR) Gregorc (1979a). Although every individual he tested demonstrated use of all four styles, 95 percent expressed a preference in one or two areas.

The following section presents a brief description of each of the four learning styles (Gregorc, 1979b).

Concrete Sequential (CS) learners prefer direct, hands-on experience. They exhibit extraordinary development of their five senses. They like touchable, concrete materials, and orderly presentations. Typically CS style learners are practical, thorough, well-organized and prefer quiet, stable and structured environments. The CS can detect the most minute details and can work with the exactitude of a machine (Gregorc, 1982a). The CS student is a perfectionist and prefers being told what to do (Butler, 1984). These learners do not like to go against the norm, view work as a job assignment, and enjoy being physically involved and active in lessons.

Abstract Random (AR) learners have a capacity to sense moods, and they use intuition to their advantage. They prefer to learn in an unstructured environment such as group discussions and activities. They prefer not to be restricted by unnecessary rules and guidelines and thus ARs tend to dislike extremely structured assignments (Butler, 1984). AR individuals are highly focused on the world of feeling and emotion and are sensitive, spontaneous, attuned, person-oriented people. Thought processes of AR individuals tend to be nonlinear, multidimensional, emotional, perceptive, and critical.

Abstract Sequential (AS) learners have excellent abilities with written, verbal, and image symbols. They like to read, listen, and use their visual skills. They are highly verbal. They prefer a sequential presentation that is rational and substantive. AS people consider themselves as evaluative, analytical, and logical individuals with a preference for mentally stimulating, orderly, and quiet environments. AS learners are generally more receptive to highly structured teaching as presented within CAL applications (Butler, 1984).

Concrete Random (CR) learners like to experiment using trial-and-error approaches. They tend to jump to conclusions and prefer to work independently or in small groups. They thrive in a competitive atmosphere and think intuitively, instinctively, impulsively, and independently. CR people prefer a stimulus-rich environments and can be risk-takers, easily jumping to conclusions. They find that they can work well in environments which encourage exploration and problem solving but like to operate according to personally constructed standards (Butler, 1984.)

Gregorc contends that strong correlations exist between the individual's disposition, the media, and teaching strategies (Gregorc, 1984):

> *Individuals with clear-cut dispositions toward concrete and sequential reality chose approaches such as ditto sheets, workbooks, computer-assisted instruction, and kits. Individuals with strong abstract and random dispositions opted for television, movies, and group discussion. Individuals with dominant abstract and sequential leanings preferred lectures, audio tapes, and extensive reading assignments. Those with concrete and random dispositions were drawn to independent study, games, and simulations. Individuals who demonstrated strength in multiple dispositions selected multiple forms of media and classroom approaches. It must be noted, however, that despite strong preferences, most individuals in the sample indicated a desire for a variety of approaches in order to avoid boredom. (Gregorc, 1984, p.54)*

With the variety of styles found in his research, Gregorc makes three inferences:

> *First, we must reassess our individual and collective viewpoints on the nature of learning. The "average child concept" is wrong! Second, we must consider multiple approaches in our teaching presentations. There are indeed "different strokes for different folks". Thirdly, we need to talk with students and verify differences within ourselves. (Gregorc, 1979a, p.34)*

As noted above Gregorc concludes that most successful students in a classroom happen to possess learning preferences that match the instructional method preferences of the teacher. He also contends that many students who refuse to accommodate to different styles may sometimes be labeled learning disabled (Gregorc, 1984).

Gregorc also notes that:

> *Learning styles emerge from inborn, natural predispositions or proclivities. An obvious implication of this finding is that individuals are capable of using their minor proclivities to varying extents and that development of these proclivities is necessary because of the multivariate demands from our environment. (Gregorc, 1979b, p.28)*

Thus as has been noted above the implication is that all teachers should use various teaching methods in their classroom. A teaching style consists of the teacher's personal behaviors and the media used to transmit or receive data from the learner (Gregorc 1979). Although it is difficult to custom design lessons to benefit all students, it is important not to use only one teaching style.

The details of how the Gregorc learning style delineator is administered and interpreted are provided in Chapter 11.

5.5 Implications for Multimedia CAL development and use

Bloom has emphasised the importance of the method of instruction on learners' attitudes towards the instructional situation and its desired outcomes (Bloom, 1956). As noted at the end of section 5.3 it has been argued that effective CAL can correct for many teachers' inability to meet the needs of all learners (Schlechter, 1991; Toh, 1996). Geisert and Dunn (1991) claimed that CAL, when implemented properly, has the inherent ability to provide individualized instruction. In the opinion of these researchers, CAL can give students the ability to:

- Work alone or in groups
- Work in varying environments
- Respond to information in a variety of ways (e.g., speak, type or draw)
- Take regular breaks and work at a time and pace which they themselves choose
- Work with or without direct teacher supervision

However, this is a view which has been challenged. A number of authors have voiced their concern that CAL may not be the preferred mode of learning for all students. An early indication of the need for a diverse approach to provision of instructional materials was given by Snow who over three decades ago commented that:

> *The development of new media and instructional technologies is rapidly expanding the variety of educational experiences with which to confront learners and is permitting individualization of many learning situations ... The concept of a single best method of instruction for everyone is like the search for the Holy Grail (Snow, 1968, p.67).*

In a direct reaction to the trend towards the pervasive use of computer assisted learning Gregorc voiced concerns that:

> *Students who cannot adapt to the demands of the medium are 1) denied access to the content and goals, and 2) are vulnerable to possible psychological damage if they cannot free themselves of the medium...Children can therefore become victims of a medium which is offensive to them. They are at the mercy of the machine (Gregorc, 1979 p.168).*

Similar concerns were expressed by Burger who cautioned against overuse of CAL noting that:

> *Requiring all students to use CAI [Computer-Aided Instruction] may not be in the best interest of the student. The matching of the teaching style of the specific computer program and the learning style of the student must be considered (Burger, 1985 p.21).*

Unlike the teacher who may be able to troubleshoot and modify lessons to meet the specific learning needs of the student (Bree & Fischer, 1979), the computer is only as good as the program that has been created for it. It is also argued that to a large extent it is not easy to detect the problems which students face when using the instructional material. (Neil, 1985)

However, it could be argued that such concerns do not reflect the capabilities of modern multimedia CAL systems which exhibit tremendous potential for providing flexibility in the delivery of teaching materials. It is argued that the use of multimedia CAL systems can be very positive because they have the potential to provide alternative approaches to learning and within a single CAL environment they can provide a range of approaches which accommodate a variety of styles of learning. However, it is important to stress that this should not be seen as an inherent property of the medium. Indeed as O'Connor notes:

> *"It is a truism in media that people first tend to use new technology the same way they were used to using older technology. In this context, the tendency is to use computing technology to deliver the same kinds of instruction & testing that are currently offered in the traditional college classroom. We assume that the same time patterns, the same content-centeredness, the same student-relations, and the same tasks (repeating known-answers) should be electronically replicated. Eventually, applications of computing technology will challenge these assumptions and free us from the need to stay trapped in older college paradigms." (O'Connor, 1999, Online)*

Multimedia CAL thus provides opportunities but only if the technology is combined with an understanding of the view of the learning process provided by learning style research and research into other individual learner differences. Such possibilities can be provided by a whole variety of approaches already referred to in Chapter 4. In particular it should be noted that the more complex activities such as simulation, games and tailored constructivist environments seem to offer most potential. Likewise, as previously noted, advances in the area of intelligent tutoring promise to provide much more adaptive interfaces (see Steinberg, 1992; Mills & Ragan, 1994). However, the general consensus is that there is still a great deal of work to be done on developing interfaces which are intuitive and come close to providing a substitute for personal communication and assistance in learning. In terms of the process of 'matching' described above Cosky emphasised the importance of providing individualized computer-based instruction to learners but also concluded that because there is a dearth of research in the area of interface design and learning styles that it may be some time before research can support the creation of truly adaptive interfaces.

Specifically with reference to matching instruction to student learning Gregorc contends that far from being an adaptive tutoring device, many students may be forced to adapt and harmonize with the computer in order to attain desired learning goals.

> *These inanimate objects lack empathy. Machines cannot sense the opportunities, qualifications, fears or problems. Nor can they sense the pressures from the forced intimacy we demand between*

> *learners and the media. Without compassion, there are no adjustments or alternative approaches offered. There is no sense of harm or restraint as the frozen medium makes its learning demands for sympathetic resonance. (Gregorc, 1985 p.168).*

Butler further asserts that

> *'Instructional technology biases the way information is presented, and demands, to varying degrees, that we use certain mediation channels' (Butler, 1984, p.237).*

In other words, the use of technology may systematically discriminate against certain learners who are unable to match learning styles with the medium. This is a view which is supported by a number of studies and these are briefly outlined below. It should be noted, however, that there are considerable difficulties in accurately interpreting the results of such studies and conclusions derived from them need to be used with some caution. In particular the reports from many authors which simply describe the fact that a computer assisted learning environment is being used in the studies do not provide sufficient detail on the CAL material itself. It is thus difficult to gain a clear picture of the pedagogical approaches provided by the courseware and hence to determine whether the effects reported can be generalised from the particular software used within the experiment.

A number of authors have claimed that CAL may not accommodate all learning styles equally but have not been supported by empirical evidence. In his essay on educational computing, Pritchard claims that CAL is suited best for individuals with an affinity for accuracy and attending to detail. (Pritchard, 1982). Moreover, the author hypothesized that individuals with certain learning styles may be more partial to learning from computers than would others, and that people who have a preference for CAL usually enjoy working alone. Hoffman and Waters state that CAL is best suited for individuals who:

> *...have the ability to quietly concentrate, are able to pay attention to details, have an affinity for memorizing facts, and can stay with a single track until completion Hoffman and Waters (1982, p.51).*

Dunn and Dunn (1979) report that certain students may only achieve through selected instructional methods (e.g., CAL, whole-group instruction, etc.), and that matching can significantly improve academic achievement. Dunn and Dunn also note that students who are motivated, require specific instructions, are sequential, and enjoy frequent feedback generally do well with programmed learning such as CAL. However, students who are kinesthetic, peer-oriented learners may not be engaged adequately by the same method of instruction. A study conducted by Friend and Cole (1990) reported that sensing-thinking individuals responded more favorably to CAL than did intuitive-feeling types. Friend and Cole postulated that intuitive-feeling types require more human interaction to achieve desired learning outcomes, and that CAL may thus not be suitable for all learners.

Other researchers have specifically aimed to look empirically for correlation between particular learning styles and performance. An investigation of such literature is complicated by the fact that research has been conducted using a variety of learning style instruments. Because learning styles instruments are often biased towards looking at a particular feature of learning style and categorise learners in different ways it is difficult to correlate the results and achieve a full picture.

Enochos, Handley and Wollenberg found that concrete learners (as determined by Kolb's Learning Style Inventory) learned more from a CAL session than did abstract learners. (Enochs et al., 1984). Cordell also sought to determine the influence of learning styles (as measured by Kolb's Leaning Style Inventory) on achievement in a CAL lesson. Two hundred undergraduate subjects were randomly assigned to either a branching or a linear program. Although results did not indicate a significant difference in overall learning outcomes, data suggested disparities in post-test results between treatment groups. Assimilators and divergers performed better with the branching program, whereas accommodators and convergers performed better with the linear program. On the basis of a post treatment questionnaire Cordell also reported that approximately half of the participants had difficulties in using the program and thus he stressed the importance of providing supplementary classroom instruction for learners to compensate for mismatching that may occur with CAL. (Cordell, 1991). Cordell's study showed the need for further research in the area of interface design to engender style matching and this has been echoed by other researchers. An interesting related study examines the manner in which learning styles affect information retrieval skills rather than directly focussing on testing a specific aspect of learning.

Wood, et al. argue that students need to become aware of their individual learning style in order to achieve success. (Wood et al., 1996). Results from their study involving groups of university students indicated that learning style (determined using the Lancaster Approaches to Study Inventory and Rider's Cognitive Styles analysis tool) affected the quality of student searches in CD-ROM information retrieval tasks. Wood et al. stress the importance of having students adopt alternative strategies when approaching computer-based instruction that does not match their prominent learning style. Such strategies require students to be aware of mismatching incidences, and have a repertoire of strategies available to employ (Wood et al., 1996). Unfortunately the authors do not go on to expand on how this can be done and although they express the need to design CAL packages which can accommodate individual learning styles again no concrete proposals on how to do this are presented.

Dahl investigated the effects of learning styles on human-computer interaction (Dahl, 1991). The GEFT (Group Embedded Figure Test) was administered to eighty-four subjects in order to determine field dependence/ independence. Subjects were then randomly assigned to either a simulation group or a drill-and-practice group. Data revealed a significant three-way interaction between gender, CAL strategy and learning style. Female field dependent students in the simulation group performed significantly poorer than did field independent female students in the same group. Again the researcher noted that results illustrate the importance of matching learning styles to computer-aided learning. This is in contrast to findings reported by Burger who found no significant differences to exist between learning style groups (again measured as field dependent/ independent) and achievement in a computer application undergraduate course (Burger, 1985). However, Burger did note that those who showed a preference for using computer technology (measured by a questionnaire devised by the researcher) performed significantly better in the final exam than those who showed more negative views.

Likewise, Liu and Reed (1994) when investigating the effects of learning styles and human-computer interaction found no significant differences between learning style groups and achievement levels. The Group Embedded Figures Test (GEFT) was used to separate university subjects into field dependent/independent categories. The researchers used patterns of behaviours (e.g., use of video, text and time taken to complete the CAL program). Thus navigation style and learning styles were used as independent measures. A hypermedia language tutorial program was used to collect data. The results showed that hypertextual, multimedia-rich environments allowed learners to modify instruction to meet their needs. Learners, regardless of being field dependent or field independent, performed equally well on tests measuring learning outcomes. Although learning style groups achieved comparably, there were significant differences between human-computer interactional behaviours and learning style groups. Data suggested that learning style groups interacted differently with the program, but achieved comparably.

There are also some studies which examine the question of links between CAL and learning styles specifically in relation to Gregorc's work. Though not confirmed by empirical tests according to Gregorc (1985), sequential students (CS and AS) will tend to prefer CAL because the computer is seen as an extension of the sequential person's mind.(just a very structured lecture approach in education is best suited to AS learners (Gregorc 1982b)). Random individuals (CR and AR) require environments which are flexible and provide opportunities for multidimensional thinking (Butler, 1984). AR individuals, in particular, are inherently social and enjoy learning with others (Butler, 1984). It is apparent that traditional CAL i.e. CAL which follows a behaviourist approach to teaching, does not always provide such an environment for this group of learners. Moreover, because Gregorc took the view that a computer requires sequential thinking in order to gain access to its content (Gregorc 1985), many CR and AR individuals may become flustered and agitated when problems arise with the medium. In an investigation examining the effects of learning styles (as measured by The Gregorc Style Delineator) and performance in a CAL university course, Davidson, Savenye and Orr postulated that abstract individuals would have more of an affinity for CAL than concrete students (Davidson et al., 1992). Abstractness, it was thought, would enable students to understand the workings of the computer and lead to higher motivational levels. The researchers also hypothesized that sequential learners would fare better with programming skills--skills that require linear step-by-step execution of procedures--than would random learners. Using a sample of 68 Faculty of Education learners, course assignments such as a mid-term test and a programming assignment were used as measures of achievement levels. It was found that AS learners showed higher skill and knowledge scores than did AR dominant learners. A significant negative correlation between level of AR and achievement was reported, indicating poor learning outcomes for dominant AR students. Findings revealed significant differences between the random/sequential dimensions (more so than that which existed between the concrete/abstract dimensions) as measured by The Gregorc Style Delineator.

Also making use of the Gregorc Style Delineator, Ross conducted an exploratory study into the effects of cognitive learning style on achievement and levels of interaction. Seventy subjects from the University of Calgary participated in the study. His results indicated that style did have a significant impact. Specifically he concludes that, Abstract Random (AR) subjects appeared to suffer from cognitive interference as a direct result of the CAL tutorial program. Scores in this group decreased significantly from the pre-test to the post-test. The Abstract Sequential (AS) group clearly benefited from the CAL session and showed the most significant gains in learning as measured by comparing pre and post test results. As well as examining dominant learning style an analysis by least dominant learning style scores added further evidence of differences in achievement levels. While dominant Abstract Sequential (AS) individuals recorded a higher degree of interaction with the program, the dominant Abstract Random (AR) group showed a lower degree of involvement with the same program. Concrete Sequential (CS) and Concrete Random (CR) groups appeared to be fairly equal in both learning outcomes and patterns of learning observed.

Hence, it would appear that the sequential/random dimension had more of an influence on both learning outcomes and patterns of learning than did the abstract/concrete mediation channel. The disparities between AS and AR subject performance gives support for this conclusion. (Ross, 1997).

Finally, there has been some work done on how individuals use CAL and its ability to meet the needs of learners from a different perspective. Rather than try to correlate learning style behaviour with performance in a piece of courseware of the studies, which will be described below, attempted to examine the effect on student performance when students were provided with a choice of different interfaces which were designed to accommodate different styles. Riding, Buckle, Thompson and Hagger hypothesized that the majority of CAL instructional programs ignore differences in learning style and in common with other researchers believed this to be a problem which could have a detrimental effect on learning. (Riding et al., 1989) The researchers designed a computer-based package which provided a variety of approaches (including sequential and abstract) when presenting content. Significantly, however, it did not guide students to use a particular mode of instruction. Results indicated that a mismatching of instruction, especially for lower-ability students, resulted in lower post-test scores. It was recommended that CAL designers develop adaptive interfaces in order to effectively mediate learning.

Following this recommendation an approach to researching the topic by Carver, Howard and Lavelle further demonstrated that there was potentially a direct link between learning style and performance when using multimedia CAL. The researchers found that using adaptive hypermedia interfaces based on students' entered learning style profiles helped learners stay on task and traverse through the plethora of content without feeling overwhelmed. Some learners were given mostly visual images, whereas other learners were give textual information with opportunities to follow hypertextual links.

As the authors of the study noted:

> *Adaptive hypermedia based on student learning styles provides the ability to individually tailor the presentation of course material to each student. The underlying idea of adaptive hypermedia based on learning styles is quite simple: adapt the presentation of course material so that it is most conducive to each student learning the course material. To a certain extent, each student is taking a different course based on what material is most effective for each student (Carver, Howard and Lavelle (1996)*

5.6 Conclusion

Examining the points made above the claim for multimedia CAL systems in terms of the implications which they have for developing CAL environments it is interesting to note that the model for development (See Fig. 5.1) now has to explicitly take into account the variety of approaches which may be taken because of the range of individual learner characteristics. A quoted advantage of multimedia CAL is that it provides support for a variety of different learning styles (through the provision of 'learner control' as discussed in the previous chapter). This, however, is a claim which must be substantiated – particularly if we are looking towards a future scenario in which online learning environments are becoming more common and where the user does not have a choice between 'traditional' or 'online' formats. As the use of CAL systems in educational environments continues to increase research into the area of human-computer interaction is becoming increasingly important. A few studies have examined the effects of individual difference on the use of CAL and findings generally indicate that while CAL has tremendous potential to individualize instruction there are a number of learner characteristics (e.g. motivation, degree of confidence with computers, learner styles) which may affect the quality and effectiveness of using this mode of instruction. If CAL does not accommodate all learners equally then it is important to use this as a teaching tool with caution and to recognize that this may not be the learning medium of choice for all students.

There are, therefore, still have to answer some serious questions which need to be asked about exactly how multimedia based systems should be ideally designed to facilitate learning and about the characteristics of learners which prompt them to use such systems efficiently. Currently models from cognitive psychology are being explored by a number of authors with the ultimate objective of determining a more accurate description of the complex behavioural patterns that characterise the learning process. It appears that there are some interesting links between models of learning provided by the formal analysis of information theory and linguistics and research on models of learning styles. It is suggested that the formal analysis of mental events associated with particular learning styles can help to identify individual structures and the propensity of learners to process information in a particular manner in order to assimilate new knowledge.

There are some very striking similarities in the rationale for accommodating learning styles in education and the constructivist view of learning. This can be seen, for example, in the following quote from O'Connor:

> *To understand learning style models, begin with one of the fundamental insights of 20th Century psychology: people rely on personally constructed filters to orient their relationships toward the world. These filters are responsive to a variety of factors: age, experience, internal psychodynamics, maturity, cognition, physiology, biochemistry, and so on. Since no one is capable of switching endlessly between all of these filters, it seems obvious that each individual has a unique approach he or she uses to perceive, understand, and plan his or her interactions. Information theory, for example, explains that the world is information rich and therefore people are selective in the information they perceive (& believe). Our personal way of selecting can be described as our style. In a very real sense, we*

create our own personal point of view. (O'Connor, 1999, Online)

The consequences for evaluation of multimedia CAL systems is obviously to push much more emphasis on to examining not only the learning environment but also the learners themselves in order to gain an understanding of the manner in which students use multimedia computer assisted learning. Thus for an evaluation to be meaningful it is necessary to consider all of these different variables as they may all potentially contribute to any observed changes in learning outcome. This does not necessarily mean that the evaluation must encompass a complex multivariate approach to providing detailed measures of each of these variables (some of the variables in fact would be very difficult to measure accurately). However, the design of the evaluation methodology and the analysis of results must attempt to ensure that there is a degree of confidence that the factors which are not being tested as dependent variables are common to all members of the population sample.

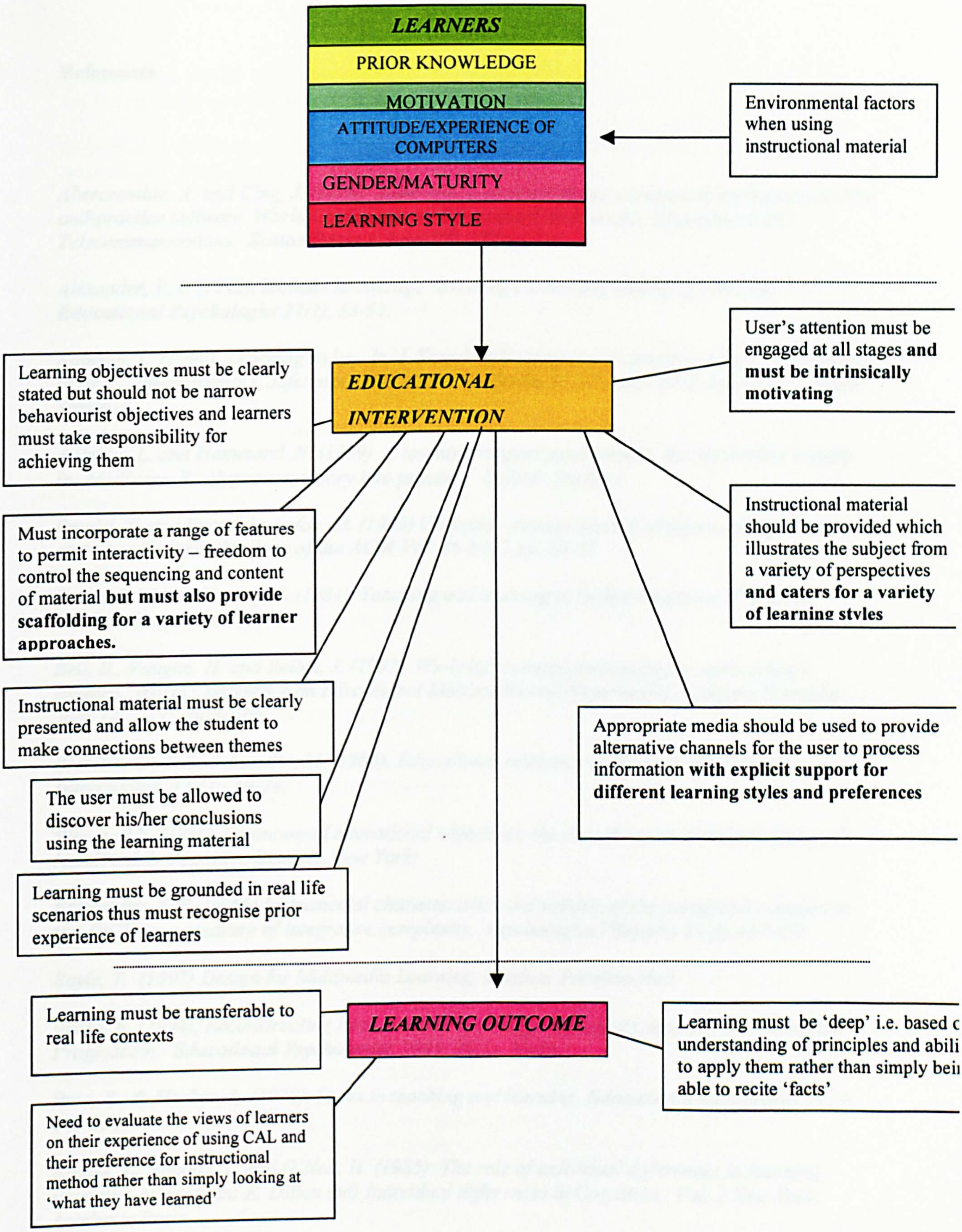

Figure 5.2 Model 3 –Computer Assisted Learning System incorporating issues of Individual Differences

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Chapter Six

Institutional Context and Educational Frameworks

> *'Issues surrounding developments in the workplace, student demographics, economic pressures, and on-line competition are forcing institutions of higher learning to re-evaluate how educational services provided are delivered to student populations. Current trends regarding the information superhighway and computer assisted instruction are the driving forces behind this systemic re-evaluation by universities.'*

(Treuhaft, 1995)

6.0 Objectives

The objectives of this chapter are to:

- review the context in which the development and implementation of multimedia CAL systems has been fostered (particularly in the United Kingdom) in order to give a more holistic view of the factors which have prompted development of such systems and which have to a large extent influenced their objectives
- to examine the development of CAL in the context of its ability to support the delivery of teaching and learning in higher education as defined by the activities which teaching and learning at this level must support (in particular the activities identified in Laurillard's conversational framework)

6.1 Higher Education Context

It is important to look further than at hardware, software and usability issues to explain the impetus towards developing multimedia CAL systems in the higher education sector. In particular it is important to examine the institutional context in which such developments are taking place in order to better understand some significant issues which have to be addressed if introduction of CAL is to be successful, and the criteria by which educational administrators will evaluate success.

An obvious feature of higher education in the past few years has been its rapid growth. Table 6.1 clearly demonstrates that growth.

Table 6.1 Unesco Figures on students engaged in higher education worldwide with projections (from Baxter and Dewhurst, 1992)

YEAR	*DEMAND FOR HIGHER EDUCATION*
1970	28 million
1990	65 million
2000	79 million
2015	91 million

This worldwide trend has been evident in the United Kingdom, and throughout the educational system in the 1990s there has been evidence of increasing student numbers and a wider variety of courses being offered to those students.(MacFarlane, 1992) Gibbs drew attention to the fact that the main focus of expansion is reflected in an increase in very large classes rather than in proliferation of smaller units and this is actively being encouraged in some institutions (Gibbs, 1992). The MacFarlane Report estimated that within the decade 1990-99 there would be an expansion by 50% of students registered on full and part time courses within the United Kingdom. (MacFarlane, 1992). At the start of the 1990s it was thus viewed as imperative that cost-effective solutions should be sought to deliver the curriculum to a wider audience. It was not only, or even primarily, the numbers of students which posed the thorniest problem for teaching staff in higher education. Rather it was the increasing diversity of the student body - diversity in terms of background experience, qualifications, age and expectations. By the early 1990s it was being overtly recognised that the demographic pattern of first year student cohorts entering university would no longer reflect a preponderance of school leavers. But it was also being recognised that the manner in which delivery of teaching was conducted had not changed to take account of this fact. Whilst the discussion below looks at the response to this problem mainly from the perspective of the United Kingdom, it is worth noting that this is not a phenomenon which was restricted to any particular country, as the following quote from the Australian report '*Steering from a distance: International Trends in the Finance and Governance of Higher Education*' illustrates:

> *'Higher education in the 1990s has been characterised by increasing student numbers, diminishing resources, increasing accountability, increased rationalisation of course offerings and an increasingly diverse mix of students (DEET, 1993, Online).*

The 1990s also saw an identifiable trend towards non-campus based education. Academic establishments had for a long time recognised the importance of maintaining and strengthening links with the prospective employers of their students and many vocational universities were overtly concerned about the ongoing training/education which extends into the workplace - this taking the form of involvement in provision of part-time courses, distance learning courses or consultancy or short courses. However, advances in technology were forcing a pace of change that was so rapid that it was becoming apparent across the higher education sector that work and learning could no longer be seen as separable. Universities were having to accept the fact that in the information society learning had to be viewed as a lifelong activity rather than as a four or five year period of concentrated activity to gain accreditation in a particular subject. Innovative projects such as the EHE (Enterprise in Higher Education) initiative sought to strengthen students' transferable skills such as information handling skills, interpersonal communication, and enterprise skills, and provoked a serious response by higher education to the challenge of preparing potential graduates for a working environment in which flexibility and the ability to learn can at times be as important as detailed mastery of a particular subject area. Because of society's changing perception of the need and value of education there is a need for the university to extend its remit to education outwith the "halls of learning" and onto the street and into the workplace. As Bates pointed out:

> *'if we wish to avoid a future scenario of a fragmented, on demand, at cost system of education then academic*

establishments are going to have to take a more active role in co-ordinating access to learning generally by providing quality mechanisms to plan, administer and accredit a more flexible range of pathways for open learning.' (Bates, 1993, p.76)

An important part of this process was seen to be the production and distribution of quality teaching materials on which this learning can be based.

Concurrent with this expansion of the higher education sector those involved in higher education have been all too keenly aware of cost restraints - particularly on staffing budgets - and the increasing prominence being given to mechanisms for ensuring that quality of teaching is maintained or improved. It is against this background that multimedia computer assisted learning was being promoted as a means to deliver the curriculum effectively and efficiently. In the early 1990s Greville Rumble suggested a future in which academic establishments co-operate formally to provide a network of learning materials. This indeed is the substance of the TLTP (Teaching and Learning Technology Programme – briefly described below) where consortia consisting of a number of linked academic sites produce generic teaching material. The success of the TLTP projects still has to be demonstrated - particularly in respect of increasing productivity and performance in education which was the ultimate goal of the political initiative under which the scheme was established. Initial reports from various projects appeared very promising; however, the overall impact of the programme has not been as great as was initially predicted. Networked multimedia technology seemed to offer a solution to some of the problems which presently face universities in delivering their current courses to a wider and more varied student audience and promised to be a significant tool to assist in preparing academic establishments to adapt to a new social context in which they will deliver education to a mass market. There has been a history of such claims and it is fair to say that many modern commentators appear to have learned little from the historical failure of technology to 'revolutionise' education. In the field of educational technology for more than three decades now there have been predictions that CAL will become the dominant way of delivering instruction both in schools and in universities. (Levien et al., 1972; Marshall & Hurley, 1996). However, as with the introduction of film and television into the classrooms between 1960 and 1970, initial promises with CAL and 'teaching revolutions' that would take place have yet to materialize (see in particular Postman, 1992; Postman, 1997). Part of the reason for this stems from unrealistic expectations placed on the medium (Schlechter,1991) but in part one can also attribute this to over optimism amongst educational administrators and funding agencies who perhaps fail to fully understand the complexity of the teaching and learning process.

As has been noted in the discussion provided in Chapters 3 and 4, it is difficult in retrospect to understand the optimism which was apparent in many of the early studies of CAL. The promised benefits of CAL were certainly not conclusively demonstrated and the evidence of what was happening in lecture rooms and classrooms demonstrated clearly that they were not being applied in practice. Despite a wealth of resources being channeled in the direction of developing course material for delivery by computer in the 1970s and 1980s (particularly in the United States) the resulting corpus of material in this format was still relatively small by the end of the 1980s. The vast bulk of teaching material was still prepared and delivered using traditional methods. Faced with the reality of what is happening in institutions of higher education and the very limited impact of CAL in curriculum delivery, it is impossible not to concur with Booth's assessment of the situation in which he states that:

> *Despite many noble efforts by the education community, realistically it is hard to point to any significant impact of computers in education other than small, isolated successes that are often the result of substantial investments of time, money and good will on the part of educators and the computing community. (Booth, 1994 p.9)*

Historically, it would seem, the case for CAL was certainly 'oversold'. However, to many commentators in the latter half of the 1980s and the early part of the 1990s a view appeared to be emerging that trends in computer technology (associated in particular with the development of multimedia systems) justified a renewed optimism in the development of CAL materials. The need identified was to develop a 'critical mass' of good quality software and this led to the drive to develop materials. Evaluation was seen as an issue but was certainly not central to the objective of funding agencies and this fact becomes apparent when examining the aims and objectives of the major funded initiatives to develop computer assisted learning in the United Kingdom.

6.2 CAL Initiatives In The UK

Over the past decade there have been 2 main initiatives in developing the role of CAL in university teaching in the United Kingdom[1] It is interesting to examine these initiatives in order to illuminate the manner in which government funding bodies have perceived the benefits of computer assisted learning.

6.2.1 Computers in Teaching Initiative (CTI)

The **Computers in Teaching Initiative** (CTI) was established by the Computer Board for Universities and Research Councils in 1985. The first phase saw the establishment of 139 courseware development projects at Universities throughout the UK. Funding for these projects ceased in 1989, but was followed up with the establishment of 21 CTI centres, each subject specific, to promote and support the effective and efficient use of computers in university teaching (CTI Phase 2). The CTI centres were reviewed regularly and new CTIs established when necessary. These centres have now been replaced by Learning and Teaching Support Network Centres which perform broadly the same function. The mission of the Computers in Teaching Initiative was to promote and co-ordinate the use of computers and other appropriate learning technologies in subject teaching, and to encourage the improvement and dissemination of software, teaching materials, and pedagogical methods. The core philosophy of the CTI was that

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[1] *There are of course a number of other initiatives which have made a substantial contribution to development of IT in the University sector in the United Kingdom. In particular the Information Technology Training Initiative (ITTI), established in 1991 by the Universities Funding Council, funded for a three year period, to improve IT training materials in UK higher education institutions and, in a Scottish context the Learning Technology Dissemination Initiative (LTDI), set up by SHEFC as part of its response to the Committee of Scottish University Principals' Report on "Teaching and Learning in an Expanding Higher Education System" (the MacFarlane Report) and directed at wider dissemination of materials arising from existing good practice in the Teaching and Learning Technology Programme (TLTP) and the Computers in Teaching Initiative (CTI). However, as the remit of these projects is not centrally the production or dissemination of courseware they will not be considered in detail. Furthermore, some of the problems in researching the area of CAL development in higher education arise because parallel initiatives aimed at increasing the level of skills and use of IT generally and in developing CAL courseware have been undertaken and at times these are not properly differentiated within the literature.*

both lecturers and students should use computers in the context of the content and problems of their own disciplines.

CTI centres disseminated information about best practice in software and teaching :

- by publishing software and resource guides and newsletters, oriented towards the needs of subject specialists;
- by running training courses and workshops;
- by visiting departments, and by advising academic enquirers by telephone, post and e-mail;
- by advising courseware developers and TLTP projects;
- by running electronic information servers.

Castleford and Robinson note that the CTI aims involved:

> *(a) assessing the pedagogical potential of IT; (b) promoting increased awareness of the potential benefits of IT for University teachers, students and administrators; (c) assessing needs throughout higher education; and (d) producing and implementing educational software. (Casteleford and Robinson, 1994, p.117)*

It could be argued that the sheer diversity of these aims was problematic. In particular the aims, although purporting to evaluate the pedagogic benefits of CAL, embody an assumption that the benefits have already been proven. This is typical of many initiatives which have involved educational technology and, as discussed in Chapter 4, is also an assumption which has underpinned some of the research work which has sought to justify contentions that multimedia CAL delivery enhances teaching and learning.

Despite high expectations that CTI centres would disseminate software products widely throughout UK Higher Education ,the difficulties of the approach taken became obvious very rapidly. No attempt was made to standardise hardware platforms and about half of the software was developed on equipment which rapidly became obsolete. Materials developed in certain universities were often deemed 'inappropriate' elsewhere (the 'not invented here' syndrome) and with few exceptions products were used only in the departments in which they were developed. The second phase of the CTI initiative was more successful but it is generally recognised that it was not funded sufficiently well to achieve a cultural change in acceptance and use of CAL and in large part this was attributed to a continuing lack of suitable courseware to support teaching at higher education level. As Slater commented:

> *In the early nineties the problem could be characterised as having support for material in place but not enough materials to support and not enough delivery of that which did exist (Slater, 1996, p.3).*

6.2.2 TLTP

The **Teaching and Learning Technology Programme** (TLTP) was set up in 1992 when the Universities Funding Council invited institutions to bid for funding to develop new methods of teaching and learning. It was recognised that many institutions had adopted a 'cottage industry' approach to implementing new technology, providing small grants to already over-worked academics, without providing the level of infrastructure and support necessary for successful innovation. TLTP aimed to overcome this problem. Two types of project were considered - consortia based projects concerned with courseware development in specific subjects, and single institution projects addressing the problems of implementation and staff development. A total of 43 projects were funded in phase 1 (1992-93) of the teaching and learning technology programme (TLTP), with a further 33 projects funded in phase 2 (1993-94), by the new funding bodies HEFCE, HEFCW, SHEFC and the DENI. Projects were subject to review, but funding was available till1996. Additional funds were allocated in 1995 for the funding of the TLT support network, with eight centres distributed though out the UK.

Approximately one quarter of these projects addressed institutional issues, particularly staff development, and worked towards the creation of an effective and sustained culture change within the host institution, to create an ethos supportive of greater use of technology within the teaching environment. The remaining phase 1 and 2 projects were concerned with the design of subject specific courseware, and most include consortia made up of academics staff from different institutions, ranging in size from two to forty-four members. The attractiveness of the TLTP project to funders of Higher Education can easily be seen when one considers some of the claims made for potential financial savings. For example Castleford and Robinson (referring to the development of courseware for teaching Geography) noted that:

Because the project aims to involve virtually all the nation's geography departments, very high efficiency gains are achievable within a short time of the project's completion. First-year teaching – inclusive of lectures, practical classes and tutorials – in some 100 departments involves more than 65,000 hours of staff time annually. If only half of the departments adopt only half of the planned materials, a considerable 4,000 teaching hours could be saved. At a notional £35 per hour this represents £140,000: it is a significant annual return on the investment in the consortium and much higher returns are realistically achievable. (Castleford and Robinson, 1994, p.121)

Indirect evidence for the failure of TLTP to deliver such results is demonstrated by the objectives of the third phase of the Programme. This was launched in March 1998 with 32 projects receiving funding which totaled approximately £10.5 million over three years. Whereas the first two phases focused largely upon the development of new technology based materials, the focus of this new phase was on implementation. There was obviously still a failure to demonstrate the embedding of new technologies into higher education. Notably, also, the new phase of TLTP gives more emphasis to evaluating its effectiveness. The objectives for this third phase were to:

- encourage the take-up and integration of TLTP materials and other technology based materials into mainstream learning and teaching;
- explore, adapt and disseminate experience from integrating such materials, to identify successful approaches that can be applied generically, rather than just to specific subjects;
- develop effective networks to deliver materials to end users;
- encourage continuing collaboration between higher education providers to develop and implement materials, using standard delivery environments.

There are of course other bodies and initiatives which have been instrumental in the promotion of multimedia CAL technology in higher education although they have not been as directly involved in developing or disseminating courseware. The work of the ITTI and LTDI has already been noted. In addition to this note should also be made of the work of bodies such as TLTSN (Teaching and Learning Technology Support Network), SIMA and ACCOG, industry supported initiatives such as the ELT (Evaluation of Learning Technologies) project at the University of North London and of course a number of discussion groups and fora accessible via the Internet which reflect the efforts of individuals or small groups of interested academics. A wealth of experience and resources has been developed within UK Higher Education within the last decade, and it would appear that the opportunity exists to take advantage of these developments, and to effectively manage the introduction and integration of CAL into the curriculum.

Thus a recurring issue which appears concerns not the design of CAL courseware itself but of the context in which it is used. It is important to note that issues related to how CAL should be integrated into the curriculum and in particular the types of functions that it can support in delivering quality higher education need careful definition. Contextual issues relating to delivery are thus given prominence in the evaluation framework which is proposed in Chapter Eight. These important issues which must be examined in order to ensure that the context in which CAL is used is appropriate. These are succinctly put in a paper put forward by the US National Institute of Health which notes that:

> *Interactive technology is more than a means to augment content delivery within a conventional educational framework: it is rather, a means to foster a new model of teaching/learning based on learners' navigation and creation of knowledge webs and as a technology at the core of an information infrastructure that could be a driveshaft for educational reform (National Institute of Health, 1995, Online).*

In this respect evaluation can be seen to be a central activity. Rather than begin with the assumption that the introduction of CAL in higher education is necessarily a 'good thing' it is important to examine how technology can support teaching and learning at this level. As Jones notes, many evaluations fail to investigate why a particular piece of courseware has been chosen or developed to deliver part of a course. (Jones, 1996) In order to fully understand the manner in which computer assisted learning can be used in higher education it is important to investigate the manner in which higher education is delivered and to provide a model which can act as a reference point when considering how technological innovations can support this delivery. As Draper notes:

> *... we need a model of the teaching and learning process in order to be aware of the main factors having a considerable effect on whether students learn. This is needed for evaluators, so that they can measure the values of these factors, and so can describe the characteristics that a future situation must have in order to replicate the finding i.e. so that the same learning gains can be expected (Draper et al., 1994, p. 14)*

6.3 Educational Framework

The more sophisticated interfaces which can now be offered for delivering teaching material is certainly one factor which will contribute to the success of any developments currently being made in this field but it is important to realise that the technology to accomplish this is not in itself the dominant factor in the success of educational courseware. The structure of a package, its language and interface are of course extremely important but what is particularly encouraging about trends in courseware design is that the development of the delivery mechanism has been paralleled by increased attention to detailed consideration of how the systems being constructed are firmly rooted in sound educational objectives and provide an enhanced learning environment. As Laurillard comments:

> *the technological pull is only benign when it is met by an equally successful pedagogical pull that keeps it on the track of the educationally beneficial (Laurillard, 1994)*

In terms of its impact on application of educational technology the most significant model to emerge in recent years is Laurillard's 'conversational framework' (Laurillard, 1993). Laurillard attempts to provide a generalised framework which describes all teaching approaches in higher education. The framework is very much based on earlier work by Pask. (Pask, 1975) Pask's Conversation Theory was based around a cybernetics framework and attempts to explain learning in both living organisms and machines. The fundamental idea of the theory was that learning occurs through conversations about a subject matter and these conversations are the actions which serve to make knowledge explicit.

Laurillard lists 12 categories of actions and interactions which she asserts must occur in a learning situation. These are shown in Figure 6.1.

Laurillard argues that there are thus four main aspects involved in the teaching-learning process – discussion, interaction, reflection and adaptation. The upper part of the model shows **discussion** between teacher and student of their respective conceptual knowledge of a subject. This is achieved at the level of description. Lectures and tutorials can both provide a forum for this discussion but in practice it is more likely that two way discussion will be achieved in small class work

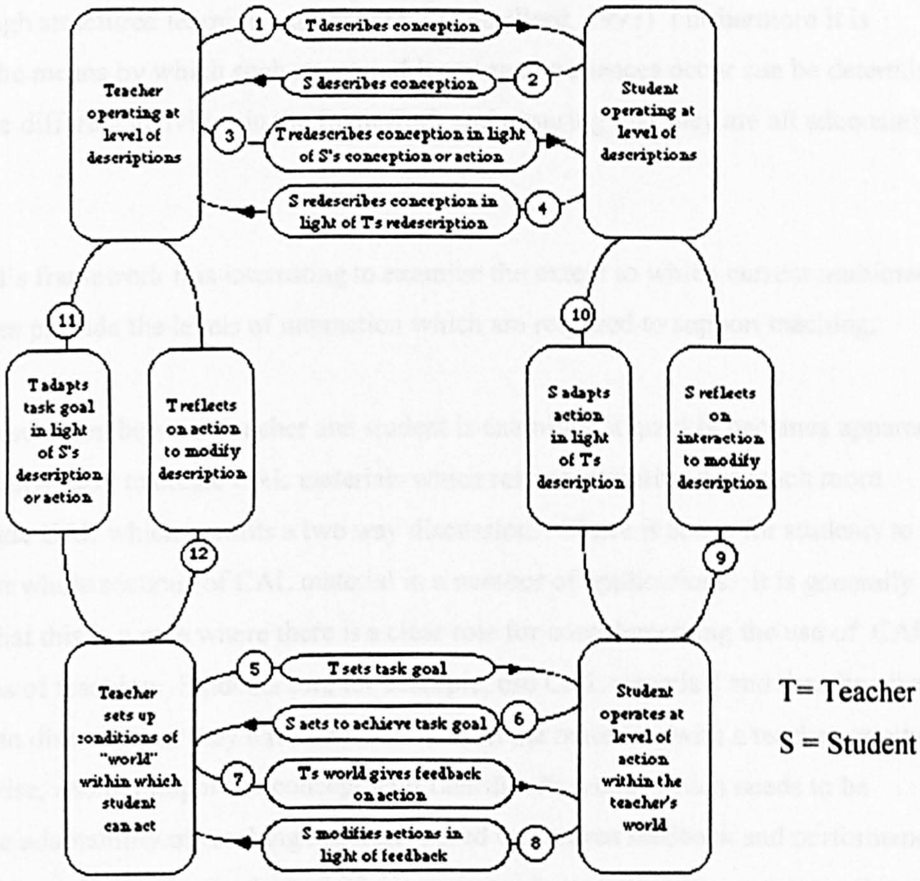

Figure 6.1 Laurillard – Converational Framework (from Rethinking University Education, 1993 p.102 redrawn by Draper et al. 1994)

The model also proposes that **interaction** also occurs on another level - the level of personal experience and action on the world. This part of the model presumes some form of interaction between teacher and learner with regard to some aspect of the world defined by the teacher. To a certain extent this proposes a division between learning 'theory' and practical application. Laboratory work or case study type work are examples of how this interaction can typically be accommodated in teaching and learning in higher education.

These two levels are joined by a set of activities which link them and which involve **reflection** and **adaptation** by both teacher and student.

According to Laurillard, design of learning is thus intimately concerned with achieving "self-realization through structured learning experiences". (Laurillard, 1993) Furthermore it is contended that the means by which such structured learning experiences occur can be determined by examining the different activities in the framework and ensuring that they are all adequately supported.

Given Laurillard's framework it is interesting to examine the extent to which current multimedia CAL programmes provide the levels of interaction which are required to support teaching.

If the issue of discussion between teacher and student is examined it quickly becomes apparent that whilst it is fairly easy to create CAL materials which rely on narrative it is much more difficult to provide CAL which permits a two way discussion. There is scope for students to take notes or print out whole sections of CAL material in a number of applications. It is generally acknowledged that this is a case where there is a clear role for complementing the use of CAL with other modes of teaching. Students can, for example, use CAL materials and then be given the opportunity to discuss what they have understood from the materials with a teacher or other students. Likewise, another important concept with Laurillard's model which needs to be examined is - the adaptability of teaching materials based on student feedback and performance (reflection and adaptation by the teacher). In doing so it can be seen that in many cases this is simply ignored in many CAL implementations. The scope for reflection and adaptation of the learning environment by the student is also very often restricted. Certainly, in some CAL applications the onus on making appropriate connections and creating a unique path through the learning material can be said to encourage this. However, it is also extremely problematic to assume that the student will be able to assume a high degree of control over such a learning environment and in most cases considerable support or 'scaffolding' is provided to allow students to make 'appropriate' mental connections. As Laurillard herself notes:

> *The paradox of interactive media is that while in a user control medium the user expects to have and has to be given control, a learner is not in a position to know enough to be left in full control (Laurillard, 1994).*

Whilst it is possible to use the computer constructively in situations in which simulations or visualisation processes are required, the bulk of the interaction between user and systems is often restricted because of the sheer complexity of developing a contextual and conceptual framework to support a fully exploratory environment. As Phillips notes when commenting on support for Laurillard's control features in terms of designing CAL interfaces:

> *Most of the student functions are not particularly difficult to program, but they may take up quite a lot of room on screen and clutter the user interface. Many of the teacher functions, on the other hand, require a considerable amount of artificial intelligence to implement (Phillips, 1997p.30).*

As noted in Chapter 4, the use of features such as note taking devices, maps and glossaries are therefore seen as useful adjuncts to assisting guided discovery learning. However, many of the cognitive tools which authors such as Jonassen advocate are extremely complex and there is an unresolved conflict in the constructivist epistemology which assumes that the learner has the skills of researcher and the reality of classroom learning where this is a skill which has to be developed as part of the learning process itself. Certainly, as was noted in Chapter 4, it is possible to devise interactive multimedia environments in which control features can be made available for both teachers and learners . These will enhance the ability of software to provide a learning environment which provides support for some of the interactions which Laurillard has identified as being important in her conversational framework for learning. However, these can only provide an approximation of the flexibility which can be achieved in a real life situation. Overall an analysis of the types of control features advocated for developing interactive multimedia environments does not provide sufficient evidence for confidence that such systems can support the complex network of interactions and support which is provided by a 'traditional teaching' environment.

If it is accepted that all activities in the framework must be supported and that these can be used as a template for measuring different educational interventions supported by CAL the conclusion must be that in itself CAL cannot be seen as a replacement for traditional teaching. If as has been shown this particular type of teaching does not support one or more of these activities then instructors can compensate for this by using another type of teaching method and the conclusion is that CAL can be regarded as a useful adjunct in certain teaching situations but other teaching methods must be used to support other activities.

Again, as discussed in Chapter 4, the other main feature of multimedia CAL which it is contended provides support for learning is the use of different media types. It is interesting, therefore, to examine this specifically in relation to the way in which Laurillard's model of teaching activities can be linked to the use of a variety of media. Laurillard provides a media comparison chart which is used to illustrate which activities are supported by different media types. (Figure 6.2 below).

	Print	Audio-Visual	Television	Video	Self-assessed questions	Hypertext	Multi-media resources	Simulation	Microworld	Modelling	Tutorial program	Tutoring system	Tutorial simulation	Audio-conferencing	Video conferencing	Computer conferencing	Computer supported collaborative work
1. T can describe conception	✓	✓	✓	✓	×	✓	✓	×	×	×	✓	✓	✓	✓	✓	✓	×
2. S can describe conception	×	✓	×	×	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓
3. T can redescribe in light of S's conception or action	×	×	×	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	✓	×
4. S can redescribe in light of T's redescription or S's action	×	✓	×	×	✓	✓	✓	×	×	×	✓	✓	✓	×	×	✓	×
5. T can adapt task goal in light of S's description or action	×	×	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×
6. T can set task goal	×	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓	✓	×	×	×	✓
7. S can act to achieve task goal	×	✓	×	×	✓	×	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓
8. T can set up world to give intrinsic feedback on actions	×	✓	✓	✓	×	×								×	×	×	✓
9. S can modify actions in light of intrinsic feedback on actions	×	✓	×	×	×	×	✓	✓	✓	✓	×	✓	✓	×	×	×	✓
10. S can adapt actions in light of T's description or S's redescription	×	✓	×	×	✓	×	×	×	✓	✓	✓	✓	✓	×	×	×	✓
11. S can reflect on interaction to modify description	×	✓	×	✓	✓	×	✓	×	✓	✓	×	✓	✓	×	×	×	✓
12. T can reflect on S's action to modify redescription.	×	×	×	×	×	×	×	×	×	×	✓	✓	✓	×	×	×	×

Figure 6.2 Laurillard – Media Selection Grid (from Rethinking University Education, 1993)

In the discussion on media and learning provided in Chapter 4 it was pointed out that attempts to define the most effective medium to represent specific information were not adequately supported by empirical research. Laurillard's approach which concentrates on the manner in which different media support different learning activities could also be criticised on these grounds. However, as her objective is to examine how media types support particular activities (rather than inferring directly that they support information transfer) her approach to media comparison is less ambitious in making far reaching inferences about media and learning. The media comparison she provides further serves to draw attention to the limited scope for multimedia CAL to support and further emphasise the case for using a variety of approaches in teaching.

Finally, it should be noted that there are some problems with Laurillard's framework – particularly because it presents an ideal situation rather than necessarily a real situation. An important factor which is absent from the model is a consideration of interaction outwith the direct teacher-student interaction. Thus for example Moore and Kearsley (1996) provide a much more comprehensive model of the nature and extent of interaction which should be included in a teaching environment. In particular they lay more stress on the manner in which the learner interacts with the content provided and also view learner-learner interaction as an important factor which must be included in a framework for learning.

As Draper notes

> *Even where the teacher is not supporting all 12 activities, some students acquire advanced learning skills which allow them to mount these activities out of their own resources (Draper, 1994, p.16).*

This is a view that could be extended to mean out of their collective resources as a 'learning cohort' or using content which supplements or extends that provided by an instructor.
It could be reasonably argued that unless the potential for direct student-student interaction and tutor-student interaction (which can be facilitated either on campus or in distributed distance learning environments) is integrated with use of CAL then effective teaching and learning cannot be supported. (Soby, 1992). This clearly points to the fact that institutional considerations and in particular contextual considerations which surround the implementation of CAL are going to have a very big impact on the outcome of any evaluation of its effectiveness. Thus again, it is an issue which the evaluation framework advocates that prominent attention must be given to.

The context in which the courseware is to be introduced will vary significantly in terms of the level at which the courseware is designed to function (e.g. replacing a full course, replacing a specific part of a course or supplementing existing teaching methods), the manner in which the implementation is supported, and the manner in which the courseware is integrated into existing delivery. Authors such as Draper and Gunn have concluded that contextual issues are of primary importance when evaluating the effectiveness of a particular CAL implementation and this is discussed in more detail in Chapter 8.

6.4 The tension between cost effectiveness and quality of learning

When one examines the manner in which multimedia CAL has been introduced into higher education in the United Kingdom it becomes apparent that the reasons for the introduction of CAL (and one would logically therefore conclude an important factor in evaluating its success) includes a far broader range of factors than learning outcomes alone. In particular an important factor in determining the uptake and use of educational technology, as noted in the discussion of the objectives of the TLTP programme, is cost effectiveness. However, despite the overt recognition by the funding councils that this issue is of significance, the issues involved in evaluating cost-effectiveness of CAL are very poorly developed.

A central reason for this is that the economic advantages and disadvantages of educational technology use are not obvious. As Hawkridge notes, for example, courses which are costly in terms of resources may have extreme long-term benefits (Hawkridge, 1993) in terms of unique training or education in an innovative subject area making use of very specialised expertise. It is also argued by some authors that multimedia CAL based courses may have unique qualitative benefits, which cannot be easily quantified and costed. Thus whilst the economies of scale involved in collaborative development of courseware may be expensive in terms of creating the initial product, it may offer competitive advantages by producing designs that would otherwise be impossible (Scott, 1997).

Some features recur in the literature as justifications for the economic effectiveness of educational technology use. These include, for example, the increased accessibility of teaching materials, effects on student learning time, and efficiency of product life-cycle costs for learning materials (covering development, delivery and support). Such factors have a long historical pedigree and as noted in Chapter Three have been used since the early attempts to introduce CAL using large scale systems such as PLATO and TICCIT. In order to accommodate these factors a common approach is to derive an equation for cost effectiveness based on comparative costs (per hour or per day) of delivering teaching to a target group of learners using traditional techniques and computer assisted learning (Boucher, 1998; Scott, 1997; Dillon, 1997). Scott puts forward a method which suggests that costs be separated into two parts: development and delivery (maintenance treated as part of the delivery costs).[2] Taking these factors into account suggests that IT-based solutions are almost always more expensive in terms of delivery costs than their traditional equivalents (Scott, 1997).

It is difficult to see how 'average costs' such as costs per person can be accurately calculated when use of open-access resources varies from student to student and indeed the benefit derived from the material will vary from student to student. Again, as Hawkridge notes, learning outcomes are so qualitatively different that attempts to make such comparisons become unprincipled. (Hawkridge, 1992)

Finally there are a whole range of hard 'economic' or 'accounting' factors which are hardly ever given any attention in the literature. Factors such as inflation , hardware and software depreciation, insurance of equipment, comparative costs of grades of staff involved in CAL development and delivery and perhaps most difficult of all to quantify, the effort which was expended in development and delivery of CAL which is evident in staff effort but is delivered outwith 'paid' contact or development time. Additional IT skills training or even programming expertise may be necessary for CAL development or may be a skill which a particular staff member already possesses or one which he/she is willing to acquire independently. In attempting to determine the cost effectiveness of technology based interventions in education there are often problems because it is difficult to disentangle the costs themselves from the responsibility for meeting the costs. Scott notes that although many general costs will be met at an institutional level, some may be passed on to departments, to the individual, and so on (Scott, 1997).

Solutions are possible for some of the problems which have been identified above but overall there is no evidence from the literature which would suggest that we have anything approaching an accurate costing model. Certainly there appears to be no justification for the view that this can be addressed by simplifications such as averaged comparative costs. The same argument is true when one considers the view put forward by some commentators that educational benefits must be derived from hard evidence such as course failure rates or non-completion rates. (Mason,

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2 *It should be noted that this separation of development and delivery is not uncontested. Draper, for example, provides a convincing argument based on the premise that a teacher in higher education has the role of mediating learning using a variety of different tools and there is no justification for taking an approach which views courseware as being different from textbooks or other forms of learning support material. Thus costing for teaching in general is going to be very difficult. (Draper, 1997)*

1992). This is hardly an ideal measure of cost effectiveness, but nonetheless it is argued that it does provide some measure of success in determining whether the investment in CAL is viable at an institutional level. The important point, however, is that as with evaluation of CAL in terms of educational benefit, an over concentration on outcome measurements is not sufficient. Comparative evaluations of cost-effectiveness are subject to the same problems and criticisms as comparisons of educational effectiveness.

Overall, therefore, the arguments currently being advanced to provide a justification of cost effectiveness are based on a very unsophisticated approach to evaluating cost benefit. Doughty, thus proposes that because the basic measures used are extremely crude it is best to consider simplified cases where one can confidently judge success on the basis that:

- while costs were held to about the same level the quality of learning was increased
- costs were decreased but learning quality remained the same;
- costs were decreased and the quality of learning was increased. (Doughty, 1999)

This is similar to Hawkridge's approach which is that, assuming that the educational benefit of the intervention can be judged against the situation in which no courseware was used, then one of three questions can be used to structure comparisons of efficiency:

- if the innovation's benefits were identical, how did the costs compare?
- if the innovation's costs were identical, how did the benefits compare?
- if the innovation's benefits were greater than those of traditional methods, and extra costs were incurred, are these justified? (Hawkridge, 1992)

Costs in such cases must be calculated purely on an 'additional cost' basis i.e. any material or staffing costs which had to be expended in order to develop and deliver the courseware should be calculated and cost savings associated with the delivery of the course using the CAL material should be taken into account.

It is interesting to examine the issue of cost effectiveness from the point of view of the assessment of the Teaching and Learning Technology Programme as this illustrates just how poorly developed this aspect of courseware evaluation has been. As Allen et al concede:

> *If the achievements of TLTP were to be measured purely against the efficiency gains implicit in the original objectives* 'to make teaching more productive and efficient by harnessing modern technology' *then we confess that at present the gains are hard to substantiate (Allen et al., 1996 p.17)*

This demonstrates that, not only are evaluations of cost benefit problematic because of the lack of a robust method of implementing them, but that also there is a lack of awareness on the point of evaluators of the importance of attempting to provide them (even when they acknowledge that this was part of the objective for which developments were being instigated). This is confirmed by Slater who comments:

> *Whilst there are several studies coming out of TLTP which pointing to better learning, there are relatively few that show any direct cost savings. (Slater, 1996 p. 4)*

These are important conclusions which are arguably not pursued as vigorously as one would expect in the literature of evaluation. If a system has been developed collaboratively for use by a number of different institutions it would seem reasonable to incorporate the extent of its use and portablility as being an important element in evaluation and failure to achieve this objective is a serious defect which should be prominently featured in an overall evaluation (irrespective of how successful or innovative the approach has been). However, rather than dwell on the issue of how (or if) economic gains can be made most commentators restrict themselves to the argument for increases in quality. Thus, Mayes points to a significant dichotomy of purpose in development and application of CAL in the United Kingdom as follows:

> *The overall context in which the debate about education and training are both currently being conducted is one in which strong forces are pulling in opposite directions. One of these is the over-riding need to make advanced education and training more cost effective, and thus to deliver it to a far higher proportion of the population than at present. The other is the need to raise its quality and relevance to work. (Mayes, 1997, Online)*

Oliver summarises a number of factors which are problematic in measurement of cost-effectiveness, most of which have already been noted but argues that these also have to be viewed in conjunction with arguments which are centred on the ability of the technology to improve the quality of learning. He cites a number of intangibles such as:

- Improved quality of learning experience, and a shift from passive to active learning
- A change in institutional culture, especially in the ability to exploit technology
- Improvements in transferable skills such as independent study or IT knowledge
- Improved teaching material quality
- Increasingly flexible student access to learning materials, from both on-site and off-site (via computer connections)
- The ability to construct learning experiences not otherwise economically or ethically practical (e.g. non-destructive testing or simulations of dissection) (Oliver, 1999)

Some of these advantages in the use of educational technology do not incur extra resources. This makes them extremely difficult to include in calculations of efficiency, since measurements of benefits cannot necessarily be linked to the allocation of additional resources. Within the literature on CAL evaluation it is obvious that the concentration of effort has been on demonstrating improvements in quality of teaching. Indeed in their evaluation of the TLTP programme Coopers and Lybrand have noted that:

> *An original TLTP objective was to make teaching and learning more productive and efficient. Our fieldwork suggests that this objective became less prominent as the programme progressed; the emphasis instead has increasingly been placed on quality improvements. The academics to whom we have spoken have certainly been much more comfortable with the concept of working towards improving quality than improving efficiency. (Coopers and Lybrand, 1996, p.61)*

Whilst recognising the importance of other contextual considerations it has to be concluded that the most important consideration in terms of context is to examine the rationale for introducing CAL in higher education and to clearly define whether the basis for the development is driven by the requirement to improve quality of learning, to improve the cost effectiveness of delivery, or, of course, to do both.

The implications of the discussion provided above for modelling the important features of CAL in higher education is that additional factors must be considered.

Firstly, it has been noted that technology based teaching has been viewed as a potential solution for enabling teaching approaches to deal with a more diverse range of learners. This has to be reflected in both the design solutions presented for CAL interfaces and, if this argument is to be sustained, it must be demonstrated that courseware is capable of supporting a wide range of learners. As discussed in Chapter 5, this raises the issue of computer confidence and familiarity with basic computer skills as a pre-requisite to learners being able to take advantage of the courseware and it also raises the issue of how other individual differences may have an impact on the acceptability of CAL. It can be accepted that current teaching practices based largely around lecture delivery do not serve all learners equally. However it is important to be careful to ensure that if these are to be replaced by CAL courseware the same problem is not simply replicated a different but nonetheless significant cohort of learners is disadvantaged.

Secondly, from the perspective of designing appropriate 'educational interventions' there is obviously an expectation on the parts of funders of courseware to ensure that the costs of development and application of technological solutions are cost effective. Allen et al contend that:

> *Funding councils and some senior university management tend to see learning technology primarily as a means of bringing about efficiency gains ... (Allen et al., 1996, p.14)*

This perhaps overstates the case but it does draw attention to the fact that there is an imperative to ensure that courseware which is developed is sustainable and it is unrealistic to ignore the issue of cost and concentrate solely on demonstrating quality. Issues of portability of courseware, of collaborative design solutions and of ensuring effective promotion and use of courseware are all increasingly important. In terms of the model of CAL courseware development presented in Figure 6.3 such issues may not have an immediate impact on the learning outcomes which the courseware was developed to address, but if economic considerations are ignored it will have a marked effect on the ability to sustain delivery.

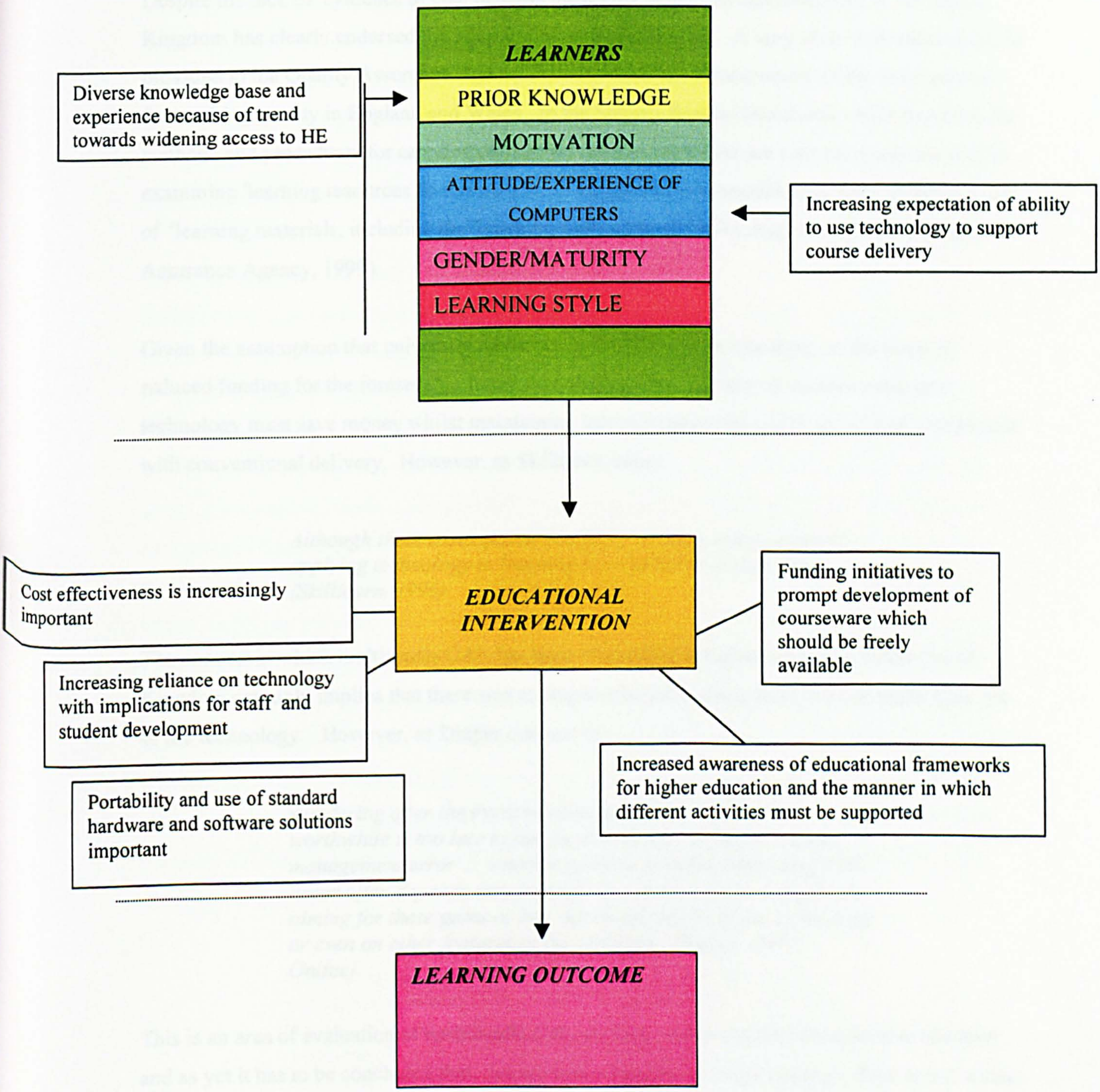

Figure 6.3 ***Model 4 Computer Assisted Learning System incorporating issues related to changes in Higher Education and Framework for delivering Higher Education***

6.5 Conclusion

Despite the lack of evidence of cost benefits the higher education establishment in the United Kingdom has clearly endorsed the adoption of multimedia CAL. A very clear indication of this is provided in the Quality Assurance Agency criteria which are a cornerstone of the audit process for teaching quality in England and Wales. In the Subject Review Handbook which describes the methods and procedures for carrying out subject review, reviewers are directed under the section examining 'learning resources' to ensure that IT equipment is accessible and appropriate in terms of 'learning materials, including the Teaching and Learning Technology Programme' (Quality Assurance Agency, 1999).

Given the assumption that university resources in the UK will be operating on the basis of reduced funding for the foreseeable future then the ongoing delivery of courses using new technology must save money whilst maintaining learning outcomes which are at least comparable with conventional delivery. However, as Skillicorn notes:

> *Although these assumptions are fairly obvious, many projects applying technology to learning have failed to absorb them (Skillicorn, 1998)*

The context in which multimedia CAL has been introduced in higher education in the United Kingdom certainly implies that there was an implicit belief in gains that could be made from use of the technology. However, as Draper comments

> *wondering after the event whether it can be shown to be worthwhile is too late to put good measures in place: a basic management error ... whether gains or benefits from using CAL occur often depends very strongly on whether those doing it are aiming for these gains or not, not on the merits of the technology or even on other features of the situation. (Draper, 1997, Online).*

This is an area of evaluation of multimedia CAL systems which requires considerable attention and as yet it has to be concluded that, despite some attempts at rough costings, there is not a clear methodological approach which can be applied to establishing true costs of multimedia CAL delivery and development. Even less work has been done on establishing a realistic cost model for 'traditional' delivery against which such costings should be compared.

The potential benefits of developing and using multimedia courseware thus have to be examined in terms not only of quality but also of cost. The most dramatic cost savings are arguably those in which CAL software can be used as an effective replacement for face to face teaching. However, it cannot be contended that multimedia CAL can be effectively used as a complete replacement for traditional face to face teaching. It does not in itself meet all of the requirements for this activity as defined clearly in Laurillard's framework.

This said, the advances in networked multimedia CAL and the development of tools and techniques to assist tutor-student and student-student interaction has been widely reported in the literature as providing an expanded potential for multimedia CAL. Striking evidence of this is to be found in the growing literature on distance education and the potential of using networked CAL for the delivery of whole courses or modules in higher education (notably through delivery of web based instruction). A full discussion of networked distance learning delivery is outwith the scope of the current research but it is useful to emphasize that whilst a great deal of interest and enthusiasm is currently evident surrounding the ability of advanced learning technologies to promote effective student learning through enhanced remote communications systems, there is still an important question to be resolved concerning the format of delivery of the teaching materials to support this interaction. There is considerable support in the literature for the view that multimedia CAL can contribute substantially to an improvement in quality of teaching and learning by presenting educational materials in a format which encourages user engagement with teaching material. The issue of how exactly the quality of such material is evaluated is still an important one and is as significant in Internet based environments as in stand alone courseware applications. This is a conclusion which is certainly supported by the evaluation of the TLTP programme as noted by Coopers and Lybrand:

> *Evaluation could have made more of a contribution to the cumulative learning from TLTP; its relatively low profile thus represents a missed opportunity. Although projects were encouraged to undertake their own local evaluations, there was not framework or mechanism whereby project evaluations could inform the overall direction of the programme or provide evidence of the achievement of objectives at a programme level. (Coopers and Lybrand, 1996, p.62).*

This confirms the importance of evaluation as an activity which can assist in ensuring that the changes which are being made in the manner in which higher education is delivered are tackled strategically. The framework for evaluation thus must incorporate the need to examine cost models because they are obviously very important in formulation of strategy. As the 'stakeholder' perspective in evaluation is becoming increasingly prominent, it is important to acknowledge the fact that it is not only the educators and learners who have a stake in CAL developments. Institutions and ultimately funders of higher education have to be assured that investment in technology based learning is delivering the outcomes which they both expect and require.

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Chapter Seven

Survey of multimedia CAL packages

> *I do not go back as far as the introduction of the radio and the Victrola, but I am old enough to remember when 16-millimeter film was to be the sure cure, then closed-cicuit television, the 8-millimeter film, then teacherproof textbooks. Now computers. I know a false god when I see one.*
>
> ***(Postman, N., 1995)***

7.0 Objectives

The objectives of this chapter are:

- To survey a range of published CAL packages in order to determine the manner in which they incorporate different pedagogical theories to support delivery of teaching
- To survey a range of CAL producers in order to determine their views on the mechanisms by which the products which they have developed provide support for teaching and learning in higher education and steps taken to evaluate success

In order to be able to examine the manner in which CAL should be evaluated it is important firstly to recognise the diversity of CAL software. Very often the term CAL is used in the literature to cover a wide range of courseware types – from sophisticated systems which use a range of media types integrated with external resources (which may be available in digital form) to facilitate a resource based learning scenario to simple 'self contained' learning packages which seek to deliver specific information about a well defined topic and often use a limited range of media types.

To identify an evaluation strategy which encompasses all types of CAL software it is useful firstly to develop a means of classification of these systems as, from the discussion of the overall objectives of such packages which has been given in Chapter Three and Chapter Four, it seems highly probable that the manner in which different systems should be evaluated will vary. A number of classifications of types of CAL software have been proposed but by far the most common approach to classification has been to examine the different types of activities supported by educational software or courseware.

7.1 Classification of Activities supported

Within a particular CAL package there are a number of different activities. Blease in attempting to provide a checklist approach to categorising software for purchase identified four main types of CAL package based around such activities and these were:

- Tutorial programs
- Drill-and-practice programs
- Games (Arcade-type games and simulation games)
- Laboratory simulations

In addition Blease notes the development of a number of 'content free' tools i.e. tools developed specifically to assist the learner whilst working on-line e.g. specialist calculators, on-line 'data books' or reference tools. (Blease, 1988). However, in reviewing CAL applications that are currently available for use in higher education, it is apparent that it is often the case that they employ a mix of the different approaches which Blease identifies.

A more useful categorisation of CAL software, however, can be derived by investigating the purpose or educational objectives which these different activities are designed to support and specifically the pedagogical approach taken in their design and integration into the package as a whole.

7.2 Classification by Pedagogic Objectives

A classification by pedagogic objectives has the advantage of providing a clearer picture of the range of possibilities for CAL to support a number of different curricular objectives. The discussion of educational theory and the role of educational technology in supporting a variety of pedagogical objectives as provided in the preceding chapters indicates that the different CAL activities identified by Blease can broadly be seen as supporting different pedagogical objectives. Broadly we can categorise pedagogic objectives as being constructivist, cognitivst or behaviourist. The characteristics of these pedagogic theories has been discussed in Chapters 3 and 4 but inevitably there is not an exact correspondence between the theoretical approaches and the manner in which these have been implemented in practice in particular instances of courseware.

7.2.1 Drill and Practice Sessions

Drill and practice sessions provide feedback and practice on a topic taught to the student at a previous time, sometimes via a different instructional method. An example of this would be giving the student a program to practice typing skills after the student has learned the layout of the keyboard or using the computer to provide drilling in vocabulary for language teaching. Essentially these approaches support clearly stated behaviourist objectives and cannot be claimed to support development of higher cognitive skills. A good example of such material is the early versions of courseware provided by the TLTP TELL consortium.

7.2.2 Tutorial Sessions

During tutorial sessions, the computer provides the student with new information. The student interacts with the computer much like a student would interact with a tutor in a one-to-one session. Concepts are presented to the student, often the student's understanding is measured, and the computer then provides more instruction or remedial instruction which may be based upon his or her response. The extent to which the system provides an environment which engages the learner is variable and is largely dependent on the extent to which the design of the system provides functions which allow the user to interact with the material being presented. This may be done in terms of either allowing personal control of the manner in which the material is accessed or providing adaptive responses and different teaching strategies depending on user input.

7.2.3 Games

Games can be used to teach and/or reinforce students' skills and knowledge. There are a number of types of games but those which are most highly developed for teaching generally involve the use of some form of role play in order to accomplish an imagined task. The main advantage of these games is generally associated with increased motivation but increasingly it is being recognised that such systems have potential for developing students' ability to construct their own knowledge and to engage in problem solving. In some cases this can be designed to allow collaborative working and meaningful engagement in 'real life' tasks. Thus such systems have the potential to be very effective tools for developing constructivist environments.

7.2.4 Simulations

Computers can be used to simulate scenarios in which students can experience the results of good and bad decisions without risky or expensive consequences. Again it is the manner in which simulations are used which is likely to determine how well this type of intervention contributes towards the development of an engaging and interactive environment for student learning. Whilst there are many examples in the literature of simulations which claim to make a substantial impact on the motivation of students to learn and which considerably enhance key skills in applying learning to real life environments some authors have sounded a note of caution in this respect. For example McAteer and Skett note in the evalation of the use of PharmaCALogy, a CAL package implemented in the Institute of Biomedical and Life Sciences at Glasgow University, that:

> *Few students clearly felt that physical labs should be entirely replaced by simulations as the acquisition of skills in experimental procedures was seen as valuable. (McAteer and Skett, 1997)*

In addition Edwards cautions against the use of simulations and questions their usefulness as a replacement for 'hands on' practical sessions for anything other than cost saving purposes. (Edwards, 1997). Generally interactive simulations are categorised in the literature as important components of constructivist learning environments.

A classification of educational courseware by pedagogic objective provides a more robust basis for evaluating CAL. Claims made for the effectiveness of CAL in teaching are often based around the fact that multimedia CAL can support student learning which goes beyond passive acceptance of facts and rote learning. This being the case it would be expected that in a practical examination of CAL this would be evident to the user and that the type of activities supported by the courseware would confirm that the pedagogic objectives. It could be argued that a better basis for the classification would be to use the explicit aims of the courseware producer which may be stated in the courseware itself or in literature which related to the courseware. All too often, however, when reviewing the literature it becomes apparent that the essential purpose of the CAL software has not been fully explored in terms of providing a clear statement of the educational objectives which have prompted the development of a particular piece of courseware.

7.3 Survey of Courseware

It was, therefore, decided that it would be useful to review a sample of practical applications in order to determine the extent to which educational theories explored in previous chapters have been implemented in the development and design of the software (and where possible to examine the effect this had on moderating the type of evaluation which was conducted). The discussion is necessarily not comprehensive in terms of reviewing the many thousands of applications which have been developed over the past few years. The objective, rather, is to provide a summary of the manner in which courseware has been developed and to draw from this some general conclusions about the extent to which different types of CAL courseware have adopted different types of evaluation. It should be emphasised that the review does not provide full case studies of CAL courseware and the mechanism for categorising CAL software as exhibiting a particular pedagogic approach has been based largely on experimentation with the material or through demonstration of the material. The basis for the classification may therefore be criticised as being fairly subjective. However, in order to provide as objective a view as possible Reeve's effective dimensions of interactive learning systems (Reeves, 1994) was used as the basis for establishing the extent to which courseware exhibited a particular pedagogic approach. The dimensions established by Reeves are assessed on a non-scalar continuum and thus provide a general indication of pedagogic approach rather than a proscriptive classification.

7.3.1 Selection of CAL courseware to be reviewed

The practical review of courseware was conducted by selecting a number of courseware packages. Some of these were available over the Internet (sometimes only as 'demonstrator' packages). In addition the review considered a large number of courseware packages demonstrated at conferences and exhibitions (in particular during the AACE World Conference on Educational and Multimedia, Hypermedia and Telecommunication where an important adjunct to the conference itself is an extensive programme of practical demonstrations of CAL packages developed in a wide range of subjects). Finally the review examined a number of packages produced as part of the TLTP initiative in the United Kingdom. As noted in Chapter Two it was sometimes difficult to acquire TLTP packages. This was despite the fact that they were produced in a publicly funded initiative to assist higher education and (given that a central concern of the TLTP programme was to promote the dissemination and use of CAL) it might have been expected that they would be readily available. A useful source of such software was the ICBL (Institute for Computer Based Learning) centre at Heriot Watt University in Edinburgh which for a time acted as a form of 'clearing house' assisting academics to gain experience of using interactive multimedia packages produced as part of the TLTP initiative.

In addition to the practical examination some of the conclusions about how packages should be classified was moderated using information derived from published case studies of CAL implementations. (Hewer, 1999; TLTSN, 1996a; TLTSN, 1996b; University of Stirling, 1996) and a number of textbooks include 'case study' chapters which provide detailed information on courseware implementations. For example, Phillips provides some very detailed observations and examples of courseware produced in Australian universities. (Philips, 1997). The results of the evaluation of the TLTP projects provided by Coopers and Lybrand was a useful source of data as part of the evaluation was to review and comment on TLTP products. Many of the findings of that survey are consonant with the review of courseware conducted here. Significantly, however, the more ambitious (and well funded projects) which demonstrate the extensive application of constructivist pedagogy are products which have been developed in the United States and Australia where funding has been more generous.

In total 48 packages were examined. In some cases a practical examination of a specific piece of courseware (or a demonstrator version of it) was supplemented by an examination of any literature which had been published and provided more background information on the claims made for the courseware. As noted above, however, this did not often provide explicit guidance on objectives of the courseware or of an evaluation strategy but it did provide some further information on the context in which it was intended to be used.

7.3.2 General Observations on CAL materials reviewed

There is little doubt that the level of sophistication of user interfaces in multimedia systems has progressed very rapidly over the past five years. In particular the use of graphics and video and the provision of more professional user interfaces marks the courseware which was produced in the latter part of the 1990s as significantly different from the types of courseware being produced in the early part of the decade. As has been noted in Chapter Four this has largely been due to the technological advances in personal computing systems and the dramatic fall in cost of hardware and software to facilitate easy generation of still and moving graphics. It has also to some extent been fostered by the development of a more sophisticated and planned approach to software development which has been stimulated by many of the funded initiatives in higher education which were outlined in the previous chapter.

However, the main purpose of the review of courseware conducted here was to concentrate on changes in the pedagogic basis for developing multimedia CAL systems. As noted in Chapter Five, much of this discussion in the literature has revolved around the move from an objectivist tradition to a new constructivist paradigm for development. On this basis the review of courseware sought to categorise the packages examined on the basis of whether they could be seen as constructivist, cognitivist or behaviourist in their general approach to teaching. Inevitably in attempting to classify a wide range of work the outcome can tend to appear prescriptive rather than descriptive and there will always be those who would argue with the placing of a particular piece of courseware in a particular category. Table 7.1 below illustrates the distribution of the 48 systems reviewed into the three pedagogic categories identified above.

Table 7.1 Categorisation of multimedia CAL systems

Pedagogic Approach	*Number of courseware packages demonstrating the approach (n = 48)*
Constructivist	5
Cognitivist	5
Behaviourist	38

It should be borne in mind, however, that these are not presented here as intentionally closed, complete categories but are presented in order to assist the process of understanding some of the issues related to practical development of multimedia CAL systems and to make a case about the nature of evaluation of such systems.

7.3.3 Constructivist Learning Environments

Beginning with the most complex pedagogic approach to instructional design, a number of courseware packages have been developed to support constructivist models of learning. Three such types of courseware which have received a great deal of attention are Anchored Instruction, Cognitive Apprenticeship and Goal Based Scenarios. The Anchored Instruction model attempts to solve the problem of learners failing to transfer acquired knowledge to a new situation. According to the Cognition and Technology Group at Vanderbilt this is achieved by following the seven design principles outlined in Table 7.2 below.

Proponents of Cognitive Apprenticeship likewise hold the view that 'traditional' education is too abstract and theoretical and again the emphasis is on the development of student skills to solve realistic tasks which are embedded in authentic contexts. Furthermore learners should be guided by experts in the specific areas and thus acquire the necessary cognitive and metacognitive skills to solve complex tasks (see for example, Collins, Brown and Newman, 1989)

Design Principles for Anchored Instruction	
1	Video-based presentation of case -based stories
2	Presentation of information in a meaningful context within a 'well-formed' story
3	Generative forms of learning - solutions to stories or cases are not given and have to be created by the learners themselves
4	Embedded data - all information necessary for the task is embedded in the story
5	Use of complex problems to give the learner the opportunity to deal with complex situations
6	Use of pairs of corresponding stories to help the user generalise knowledge
7	Design of stories which are inter-connected with other areas of the curriculum

Table 7.2 Design Principles for Constructivist Environments - Anchored Instruction (Cognition and Technology Group, 1990)

Goal Based Scenario designs arise out of the view that every human action involves pursuit of a goal and learning is not an exception to this. Extrinsic motivation in terms of getting good grades or avoiding punishment are viewed as less reliable than the intrinsically motivating goal of increasing one's own capacity to act and understand. Thus Goal Based Scenario instructional software is characterised by the development of a 'mission' which the learner must achieve and this is set in the context of a realistic scenario that provides the activities which are necessary for the learner to fulfil the mission - also giving the learner the opportunity to use different approaches and make mistakes. (Schank et al., 1994). Essentially the approach is the same as that adopted in problem based learning and emphasises the transfer of abstract, deconceptualized concepts to incorporate learning activities and context. (Bednar et al, 1992; Brown, Collins and Duguid, 1989; Spiro and Jehng, 1990; McLennan, 1993). Though there is a body of evidence which supports the efficacy of such approaches in traditional environments the studies which attempt to demonstrate effectiveness of computer supported problem based learning environments is inconclusive.

The best examples of interactive multimedia CAL systems which meet the criteria for providing constructivist environments, have been developed over the last few years in Australia. The two most notable examples of such software are 'Investigating Lake Iluka'(Hedberg, 1995), 'Researching Lake Iluka', (Harper, 1998) and the 'Discovering the Nardoo' project (Hedberg, 1995). In addition the courseware 'Principles of Financial Investment' (Stoney, 1998) and 'Introduction to Inferential Statistics' (Herrington, 1999) both produced at the Edith Cowan University in Australia are extremely impressive pieces of courseware. These courseware packages all develop 'microworld' scenarios which provide an applied setting in which to undertake a well defined task. The onus is on the student to use the resources available. These include video clips (which provide 'human' input or realistic scenarios), 'real life' data, and on-line tools for manipulating data. Such systems are extremely expensive in terms of development effort.

The evaluations conducted concentrate on affective considerations and analysis of interactions and student dialogue to demonstrate 'higher order activities' and understandably demonstrate a very high degree of approval and acceptance by learners (see for example Stoney and Oliver, 1999).

7.3.4 Cognitivist Learning Environments – Pedagogical agents and adaptive interfaces

Constructivist environments may be classified in terms of their objective which is to provide a learning situation which mimics real life and in which the student must construct their own knowledge. More limited in terms of their objective is a class of CAL courseware which demonstrates an attempt to provide some form of support for the student which replaces the human tutor in roles which are more extensive than simply a 'transmitters' of information. Such support is provided by systems which incorporate 'pedagogical agents' which take on the function of supporting the student to make sensible choices about how to use the system. In an indirect fashion this type of support is also facilitated by the incorporation of some form of preliminary on-line assessment of the student's requirements to study particular parts of the course and the level at which the student should study the material and the incorporation of some 'invisible intelligence' which adapts what is presented to students by monitoring their progress in using the system. A good example of this type of support is demonstrated in a system designed by Neumann, Ziems and Hopner to assist the teaching of logistics (Neumann, Ziems and Hopner, 1995). Neumann describes how the degree of freedom of navigation in the system and the degree of difficulty of tests and exercises undertaken is determined by the user's own self-classification when starting a session.

> *"Learners are classified according to both his/her familiarity with the software (beginner, advances level, expert) and his/her prior knowledge as well as with respect to his/her learning target (overview over a wide range of knowledge or over particular fields of knowledge, detailed knowledge about particular filed of knowledge or about a specific fact etc.). In addition the learner's behavior according to the frequency of using helps (e.g. in the format of looking for definitions of terms) and preferring alternative or complementary presentations (e.g. textual or pictorial information) is recorded in a log file. These [sic] information are graphically presented, analysed by using statistical methods and interpreted by taking the learner's self assessment (prior knowledge, preferences, learning target) into account (investigation of preferences). As a result the form of presenting knowledge is automatically suited to the learner's subjective preference of getting access to the knowledge"*
> *(Neumann, Ziems and Hopner, 1995)*

When the system was used in an experimental mode as part of this review it should be noted that no obvious change in 'teaching strategy' appeared to be adopted as a result of different inputs concerning background knowledge and level. Also, unfortunately, in their paper on the subject of the system the authors make no detailed comment on the success of the approach and simply state the potential benefits.

In contrast Schoch, Specht and Weber provide a very detailed evaluation of an example of the adaptive interface approach – through the use of a pedagogical agent. (Schoch, Specht and Weber, 1998). Most works concerning the use of agents are concentrated on the technical questions related to implementing a variety of features which support 'artificial intelligence'. Schoch et al, however, provide a very interesting perspective on how learners perceive the use of such an agent. An agent was integrated in courseware designed to teach part of a course dealing with narcotics (the Adaptives Drogen Informationsystem). Students could ask for advice and the agent would advise on an appropriate strategy for proceeding. As well as this adaptive feature the system designers also implemented an adaptable feature to allow learners to improve the model through direct interaction. This was provided in the form of a learner barometer which was generated by the system and could be amended by the user.

When using this system in an experimental mode as part of this review, it was noted that ability to provide feedback to the system was fairly restricted and the range of choices offered by the system were largely confined to suggestions to process parts of the information in a particular order or to omit certain parts of the module. This viewpoint, gained through practical use appears to be borne out in student comments as reported by the authors (Schoch, Specht and Weber, 1998). However despite the evidence provided by the authors in their paper they still make the contention that "there is remarkable evidence that the actual use of ADI as a personal mediator to individual sequencing has positive effects on learning performance". The research results presented certainly do not support such a conclusion. In fact the final evaluation failed to show any significant difference between students who used the ADI system and a control group who used a parallel system in which the intelligent agent was not incorporated. Indeed the learning performance of students who did not have the benefit of using the intelligent agent showed a greater improvement than those who used system in which the intelligent agent was included.

The results of these two projects are typical of a range of research reported in this field. The implementation of artificial intelligence and other programming devices to provide 'teacher scaffolding' in multimedia tutoring systems shows considerable promise but thus far has failed to provide positive results.

A less sophisticated approach (at least in terms of programming to support interaction) but one which can be seen as having the same overall objectives of assisting learners to make best use of the CAL material is typified by what have been termed Guided Discovery Learning Systems. These are firmly grounded in cognitivist principles and perhaps the best example is CLEM (CORE Learning Environment for Modula-2). Having identified the program as part of the literature review for this research a demonstrator copy of the courseware was acquired and assessed. Whilst the system did not employ overt guides in the form of intelligent assistants to direct students there was obviously an inherent structure in the presentation of the module material which provided a logical sequencing of information and activities embedded in the courseware. In fact the literature indicates that the CORE (Context Objects Refinement Expression) environment on which it was based was a well researched design methodology which embedded a strong guided discovery learning environment within courseware. (Boyle, 1994). The CORE principles (largely derived from research on language acquisition) have been applied to a variety of domains using a range of media, for example, VirCOM – a system in which students learn about the architecture of computers and DOVE (Dynamic Observation in Virtual Environments). (Boyle, 1997).

Whilst some courseware, thus, shows a level of sophistication in implementation of cognitivist theory when one examines the manner in which such material has been evaluated the emphasis on what is being evaluated does not always match the approach taken. Boyle et al. for example in discussing the evaluation of CLEM do not discuss in any detail the contribution of the design principles to learning outcomes and present only the results of summative tests on the subject as justification for the effectiveness of the approach. (Boyle, 1994) As noted above Schoch et al. appear to contradict the results of their study in claiming success for their approach whilst admitting that the adaptive agent – a central pedagogic device in the courseware – was not valued by students.(Schoch et al., 1998) Yet other studies do attempt to provide a rationale for student affective responses to using the courseware but still fail to correlate this with the specific pedagogic methods employed.

7.3.5 Behaviourist Learning Environments

Finally the bulk of CAL software which was surveyed (38 of 48 packages surveyed) tended to be very 'book-like' and were categorised as essentially behaviourist in approach. Certainly many of the systems reviewed had attractive well-designed interfaces and a number of them also incorporated use of simple simulations. However, from practical examination of the systems they could all be categorised as being typically behaviourist in their outlook. The emphasis of the courseware appeared to be the transmission of information to the learner. This was supplemented by simple quizzes (often multiple choice questions) to check periodically that the information had been accurately transferred to the learner. A further indication of a behaviourist approach within the courseware is this approach to embedding assessments of learners within the courseware. Whilst it is recognised that assessment and feedback are important elements of learning, the assessment instruments provided in the CAL packages surveyed was fairly basic. It is generally acknowledged that the type of instuments used (usually devices such as Multiple Choice Questions, True - False questions, simple responses which constrain the student to provide a very close match to the 'correct' answer, and ranking of items) are not instruments which are useful in assessing learning at anything other than a fairly shallow level.

This is a finding that one would not expect from the literature that generally provides a picture of a very dynamic approach to pedagogy in courseware design. It is also surprising given the almost universal acceptance of the fact that multimedia CAL courseware is not well suited to simple transmission of information[1] – a task which is better handled by books and lectures - that the dominant design methodology is very firmly centred on presentation which is more appropriately used for traditional published formats. Books provide simple portable format and their use is enhanced by a whole range of visual cues and have formal mechanisms (contents lists, chapters, footnotes and indices) to allow users to easily find information. These functions can be built into multimedia programmes but are rarely integrated in manner in which their use is intuitive. Most significantly perhaps there is a huge cost differential. Traditionally published academic texts are produced and delivered at costs that are a small fraction of those associated with even simple multimedia developments. However, although, as noted above, there are exceptions the overwhelming majority of the many packages which have been surveyed are extremely book-like and appear to reflect a traditional didactic style which attempts to transmit knowledge to the student. It is perfectly natural for academics as developers of such courseware to follow this route – traditionally the role of the academic expert has been to espouse an argument in a structured linear format and to impose a structure of knowledge on students. Thus we arrive at purely didactic models for teaching where very often interactivity is limited to permitting students to select a particular start or end point or use a variety of controls to give additional information, explain points in more detail or initiate graphics, animation or video sequences.

To further confirm the impressions of the courseware gained from practical examination, published reports or articles were identified for some of the systems which were examined and categorised as behaviourist. In many cases this literature made claims that the systems were based on 'sound cognitivist approaches to learning'. However, not only was this claim not borne out by an examination of the systems through practical use but it was also borne out by the literature relating to how these systems had been evaluated. In no case was it apparent that the evaluation of the systems was based on using assessment instruments that adequately provided a measure of any changes in cognitive ability of the subjects involved in testing the CAL material. In some cases this may have been because the literature concerning the evaluation lacked detail but overall the main issue to emerge was that evaluation was conducted on the basis of testing behavioural outcomes after use of the CAL package. (A list of the packages examined is provided in Appendix 3).

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[1] *In cases where material is hard to visualize or dynamic processes are important to assist understanding e.g. simulations of expensive or dangerous experiments or complex processes in which a visually reduced mechanism of action may be required in the form of an animation sequence there are obviously advantages to using multimedia.*

Thus, despite the claims in the literature relating to the potential for CAL to individualise instruction a survey of systems show that the majority of CAL applications do not at present have 'intelligent interfaces' nor are they designed to take into account individual learner differences. This is a significant problem as they cannot provide useful interaction with the students and in particular they cannot automatically change the manner in which concepts and problems are presented and provide feedback to the student which is comparable with the educational experience provided by a teacher.

These disadvantages have led some commentators to question the value of multimedia computer assisted learning. Reeves, for example, whilst noting certain exceptions to this, comments that:

> *"Personally, I do not have as much faith as some in our field seem to have in our ability to design multimedia that consistently engage students in high levels of interactivity in the format of tutorials or simulations" (Reeves, 1996, Online)*

It is interesting to note that the conclusions of the survey – in particular with respect to pedagogic objectives which courseware generally exhibits – are confirmed in the evaluation of the TLTP programme. In the evaluation executive summary it is noted that:

> *A surprisingly large number of products were in the style of software design which we have called hyperstack, in which material is presented to students via hypertext screens and student input is evaluated by the system. We found such systems variable in quality and often lacking in imagination ... [and] ... hyperstack style software appeared to be more effective in subject disciplines which required factually based, closed-task learning (Coopers and Lybrand, 1996)*

Thus the review of packages described in this chapter appears to be confirmed by a much larger national study.

7.4 Implications for Evaluation

Observations made in the above section should not be interpreted as a major criticism of multimedia CAL systems in higher education. One must weigh up statements concerning the limitation of the pedagogic objectives which are being supported against the very significant fact that in many evaluation studies which have been conducted concerning these systems there have been very positive results when one considers the response to the courseware by learners. However, it is important that if we are to develop appropriate evaluation procedures that these procedures must be framed in the light of the courseware objectives. In many respects the adoption of a predominantly behaviourist approach in courseware makes evaluation of multimedia CAL systems much simpler in that summative evaluation can be conducted by objectively measuring behavioural changes in terms of improvements in knowledge and understanding as exhibited in student performance using standard assessment instruments commonly adopted in higher education.

In contrast the problem for evaluation of constructivist or cognitivist systems is that it can be difficult to determine whether it is the pedagogic methodology being employed e.g. the application of problem based learning techniques or the medium being used to implement them (multimedia CAL courseware) which is responsible for any reported success. In such cases the use of instruments other than affective measures is bound to be prone to a whole range of potentially confounding variables which must be very carefully controlled.

7.5 Survey of Higher Education CAL producers

Finally in order to provide a perspective of the rationale for developing courseware using a particular pedagogic approach from the viewpoint of the developers of CAL systems an e-mail questionnaire survey of 58 developers of CAL software (mainly those who had been active in producing software for TLTP programmes) was undertaken. The main objective of the survey was to gain information on how the developers evaluated their software and to examine the perceptions of courseware producers of the value and potential of the materials that they have developed. Apart from one question to ascertain whether the courseware which had been developed was still in use, open questions were asked to elicit as much comment as possible. CAL developers were asked to comment on the specific aims and objectives which they set themselves when developing the courseware (in particular any pedagogic objectives which underpinned developments), and novel features which were implemented.. They were further questioned about the mechanisms they employed to evaluate the results of their development work and the extent to which the courseware was currently being used. (The full questionnaire is presented in Appendix 2).

The response rate to this survey was very poor (21% i.e. 12 responses[2]). In order to gain further responses a series of telephone interviews targeted at developers of CAL software was conducted. This was based on the questionnaire and elicited a further 7 responses.

As described the the methodology chapter (Chatper 2) the questionnaire returns were analysed in order to categorise the themes which were emerging as being significant to producers. This involved firstly scanning the questionnaires to elicit a broad range of themes and refining these into the small range of recurrent themes under which were of concern to developers are noted below (Table 7.3). These have been categorised under three broad headings: practical problems with development alignment with pedagogical theories; the context in which the material has been developed and used; and issues related to evaluation. Where there have been a number of responses on a particular issue or where there has been a very strong statement of a particular view within these categories this has been reported in responses listed in the table.

From the closed question it is interesting to note (particularly in the light of the discussion on institutional issues in Chapter 6) that in only 4 of the 12 e-mail responses the developer reported that the courseware was still being used within the institution. It is interesting to note that in many cases there is divergence between what developers perceive to be good theory and what can be achieved in practice (particularly in relation to the formulation and support of educational aims and objectives).

Even this limited survey of CAL developers indicates that there is a clear tension between the cost constraints and pedagogic objectives of developers. The resources available and technical possibilities for realising objectives are often not matched and thus projects are often constrained by having to develop teaching materials within time and budgetary constraints whilst realising that not all design solutions and pedagogic tools have been completely implemented. In addition a significant number of comments were made on the inevitable need to develop courseware which could be easily understood by students with clear objectives which they were required to achieve

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[2] *It should be noted that in addition eight responses were received which indicated that the original developer of the CAL material was no longer employed by the institution and that there was no other person involved in continuing the work on the CAL courseware and an additional two responses which simply indicated that the CAL development work had been suspended and the courseware was not being used)*

Theme Addressed	*Responses*
Practical Problems of Development and alignment with pedagogical approach	Pressure to create resources quickly and the need to be cost-effective in terms of the budgeted amounts from projects (3 responses) The need to control design team enthusiasm for solutions which were extremely time consuming and the need to balance design/artistic considerations with the desire to produce software which retained pedagogic content as its main aim (3 responses) The inevitability of using linear approaches to learning and 'book like' approaches because of need to maintain a familiar easy to use interface (2 responses)
Context in which material is developed and used	The expectation that the material would be widely used constrained institution from concentrating on solutions which met particular needs of groups of students. (1 response strongly expressed)
	The material taught in the courseware must be assessed to encourage students to use it (7 responses) but recognition that 'technophobic' students react badly (5 responses)
	Need more support from technical staff to implement the courseware effectively (3 responses)
	Courseware sessions need to be seen as an integral part of the course and not as a peripheral extra (6 responses)
	Important to focus on the aims which the courseware is designed to achieve (4 responses) – some of the most successful examples are from very low budget projects designed to meet a specific need (2 responses)
Evaluation Issues	Important not to evaluate all courseware in the same way – need to review result in relation to resources provided to create the courseware (1 response – view expressed very strongly)
	Impossibility of evaluating success in terms of student achievement but student acceptance and positive feedback give good indicators of success (6 responses)
	Difference between the objectives of evaluation of the institution and of the developers themselves (4 responses)
	Lack of sufficient evidence does not mean things do not work (2 responses both further emphasizing that 'traditional' teaching is not subject to the same need for rigorous evaluation)
	No 'benchmark' for evaluation so no real standards on which to judge success

Table 7.3 Responses by CAL producers to e-mail survey

and that this made the adoption of anything other than a linear didactic style problematic. Finally a series of responses which have been collated under the term evaluation issues demonstrated a very wide range of opinion and comment on the need for formal evaluation, how best to conduct such evaluation and the lack of standard procedures for evaluation.

7.6 Conclusions

Taken collectively the results of surveying a range of courseware gives support for the contentions made in the literature relating to how CAL courseware provides the ability to develop environments to support learning. However, whilst a range of interesting pedagogic approaches and some novel techniques for implementing them are evident in a small number of developments, most implementations on CAL adopt a behaviouristic approach to learning. This provides grounds for developing a more clearly differentiated approach to evaluation of courseware which is based on the aims and objectives of the systems and the context in which they are designed to be used. Clearly this has consequences when considering how CAL systems should be evaluated and any framework for evaluation must take into account the various types of system being evaluated in the light of their claims to support particular pedagogic aims. In addition, evidence from the survey of CAL developers support the conclusions of the previous chapter that the contextual issues which characterise the approach taken to development and the intended use of particular types of courseware are very important in evaluation. This manifests itself at a local level where the importance of ensuring that the courseware is appropriately supported and integrated into the overall teaching environment is emphasized. It also manifests itself when considering the development of large scale systems designed for distribution and use across the higher education sector.

These findings and those reported in previous chapters contributed the basis for the development of a new framework for evaluation which is proposed in Chapter Eight.

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Chapter Eight

Evaluation Methodologies and Models

> *"When we ask 'do learning technologies improve learning' we have to remember the complexity of the system that can conspire against them working at all"*
>
> ***(Laurillard, 1994)***

8.0 Objectives

The objectives of this chapter are:

- to examine the literature related to the manner in which CAL systems have been evaluated in order to identify the problems and limitations of current approaches
- to use the discussion of the factors which influence the development and use of multimedia CAL systems which has been developed in previous chapters in order to derive a detailed framework of how such systems should be evaluated

8.1 Purpose of Evaluation

As was noted at the outset of the thesis, it is difficult to predict and measure the relative advantages and disadvantages of introducing educational technology into a course. Thus evaluation is a central issue in order to clarify whether the argued benefits of the new technology have been realised. Because the technology itself is a novel aspect of the delivery of teaching it is often the case that evaluation is centred around issues which concern the effectiveness of the technology itself – the hardware and the software and the systems methodology adopted to design novel courseware packages. However, it may well be the case that a computer system will be designed perfectly, with all the right sort of software engineering procedures, requirements analysis, and usability testing; but that the system is introduced insensitively, or it cuts across the way people have become used to working. Thus evaluation of CAL systems must take into account all of the different factors which might have an impact in a particular learning environment and relate the outcomes of using a piece of courseware to the context in which the courseware was used.

As many authors point out (Draper, 1994; Milne and Heath, 1997; Oliver and Conole, 1998) it is thus important to ensure that prior to beginning an evaluation it is vital to be clear about the purpose of the evaluation. The main focus of introducing educational technology and embedding it in the curriculum must be to support educational programmes as they seek to expound curricular elements and to assist in improving the educational methods and tools through which students learn. Within this content is of course a critical issue and thus a great deal of evaluation is focussed on assessing the extent to which the medium is appropriate as a vehicle for the content. In addition, because the manner in which the content is delivered is dependent on using a medium which is relatively new (both to producers and users) an important strand of evaluation will be to ensure that the system design delivers the content effectively. Finally, there is the issue of how the content is received and the manner in which the delivery of the content can be said to produce the desired 'learning effect' with reference to the pedagogic approach taken. There is thus a great deal of interplay between and among the purpose for introduction of the materials, the technology used, the mechanics of implementation, the course content and delivery method and, of course, the involvement of the learners themselves. It is important that a full evaluation of an educational intervention should take in as many of these factors as possible.

Another important point which should be discussed prior to a full examination of possible evaluation methods and frameworks concerns the issue of who should be involved in conducting an evaluation. The subjectivity of evaluation of multimedia CAL is evident in much of the literature when examining the question of who conducts the evaluation of courseware. As was noted in Chapter Six many of the multimedia CAL products produced in the United Kingdom over the past decade have been the result of projects which have been centrally funded. Evaluation for external funding bodies usually appears in the form of 'deliverables': weighty documents that show what the project has done, what papers and computer systems it has produced, and how it has met the goals that were specified at the start of the project. Such documents are essentially rationalisations which attempt to prove the worthiness of the work conducted. As Milne and Heath note:

> *"Ideally evaluators should be independent of the developers, whether they are academic authors or programmers. This is because developers are very familiar with the courseware and may make assumptions that a student would not make. The act of handing over the product to an independent evaluator provides a testing environment that is representative of what a user will experience" (Milne and Heath, 1997).*

However as the authors then go on to acknowledge, this is rarely the case and indeed their handbook on evaluation specifically addresses the situation in which the lecturer is both developer and evaluator.

8.2 Evaluation and Reviewing

Before examining evaluation frameworks in detail, it is useful to make a prior distinction between the process of evaluation and review as these are not always carefully distinguished in the literature. A number of authors have sought to provide procedures and methods for reviewing CAL content and drawing up guidelines or checklists for potential users of the software (e.g. Bradford, 1982; Blease, 1988; Reiser and Dick, 1990; Hubbard, 1992; Parks, 1996; French, 1986). In their simplest form such checklists can be seen as essentially simple lists of software functions and features which seek to provide information for potential purchasers of the courseware. Thus in conducting what he refers to as an evaluation of CAL software (but which would more correctly be viewed as providing a software selection model) Blease suggested a number of comparisons which can be applied to different features of courseware (Blease, 1988). Like other authors he frames his 'evaluative framework' as an extensive series of questions, intended to promote reflection about the appropriateness of the software. Questions are grouped together under the following headings: documentation, presentation and layout, friendliness and flexibility, achievement of stated aims, and robustness. Some of the questions require a simple yes/no response whereas others (e.g. the question of 'flexibility of use') have rather vague criteria attached to them. Another notable example of this type of approach is the ITMA (*Investigations on Teaching With Microcomputers*) group's guidelines for evaluation (Phillips, 1988). This was perhaps the first suggested framework for 'evaluation' of CAL which emphasized the importance of context (later to be identified as an important cornerstone of approach adopted by the TILT project). Nonetheless, the purpose of the evaluation was very much geared towards software selection and review. Oliver succinctly summarises the four distinct stages of an ITMA evaluation as follows:

- Teachers are provided with a choice of programs, and select the most appropriate
- The software is tested by several teachers, including both those with considerable and those with no experience of using computers.
- Lessons involving software use are observed
- A suite of supplementary tools are used to generate further data, such as structured interviews with teachers, interviews with pupils, and samples of work. (Oliver, 1999 based on Phillips, 1988)

The process of review was reinforced by comparison of opinions over a range of teachers. Most of the data are gathered from structured interviews with teachers. As Phillips reports, these cover a range of questions to elicit how the use of CAL promoted learning but also attempt to provide more detail on contextual factors such as teacher experience of using CAL, resources used as supplements to the CAL material etc. (Phillips, 1988). Thus the ITMA approach can be seen certainly as being more directed towards examining the impact of using technology in teaching as opposed to Blease's review approach which is concerned largely with examining issues of technical functionality. However, whilst being rigorous in its examination of how CAL courseware functions the ITMA framework does not question the assumption that CAL is an effective means for delivery of education and the purpose of review is to assist in selection of 'the best' CAL software for a particular purpose. This is also apparent in other evaluation frameworks. Thus, for example, Foshay in the guide to evaluation of PLATO programs discounts altogether the question of whether or not CAL is an appropriate means for delivering education and almost appears to see evaluation as a 'necessary evil' which must be conducted to satisfy 'administrators' noting that:

> *"There is over 25 years of research showing that people can learn from computer-based instruction, and that on the whole CBI implementations achieve greater gains in less time than large-group classrooms. However, it is still true that decision makers often want to know if using PLATO is an improvement over whatever is being done now in their program" (Foshay, 1992)*

The most serious weakness of review type forms is that they often tend to provide 'scores' or 'ratings' for courseware which do not relate directly to the stated aims and objectives of the developers. In other cases they tend to rely on particular approaches to review which again may not be closely matched to the context in which the software was originally designed to be used. As such many review type frameworks tend to be very subjective and even where there is an attempt to achieve objectivity by involving a number of reviewers (as in the ITMA guidelines) and balancing the scoring for a particular resource, they still operate at a level which provides a commentary on the overall design of the courseware. They fail to provide an effective measure of the impact of introducing the courseware in a real context and tend to say very little about the educational benefits derived from use of the courseware.

Laurillard neatly summarises the issue when she notes that:

> *There is a persistent discrepancy between the questions asked of evaluation studies in new technology, and the conclusions they come to. New users, decision makers, politicians, funding bodies, consistently ask the question 'do learning technologies improve learning?' and evaluation studies in the field consistently avoid the issue and demonstrate instead that 'learning technologies have the potential to improve learning'. (Laurillard, 1994).*

Laurillard's assessment of the current situation with respect to evaluation of CAL is one which is held by several other authors (Ehrmann, 1995, Reeves, 1997) and in order to address the issue of how to demonstrate the effect of CAL on learning, several different approaches to conducting evaluations have been proposed.

8.3 Proposed types of evaluation

Thus, in contrast to the narrow definition of the evaluation which is based on techniques to review computer assisted learning packages, it is increasingly recognised that evaluation needs to reflect a broad range of activities which attempt to measure the educational benefit or make more explicit the mechanisms by which students learn in response to introducing a new teaching method. Such studies tend to be distinctive in outlook because (at least in theory) they are designed to tackle the fundamental question of whether an improvement in the quality of learning or effectiveness of teaching can be detected.

In this context it is suggested that evaluation has a number of different roles or purposes and it has thus been proposed that different types of evaluation are required in order to:

- provide an effective measure of the quality of the courseware being introduced (formative evaluation);
- explore the manner in which the resource is used and its perceived value to students (illuminative evaluation);
- examine issues related to the integration of such material into an existing course of study (integrative evaluation);
- confirm that the courseware has a 'proven' benefit (summative evaluation).

In the light of the discussion in the Chapter Six one could add

- demonstrate that the introduction of the courseware is economically viable in terms of delivering the same educational benefit at a reduced cost or enhanced educational benefits at the same cost

The different types of evaluation were discussed briefly in Chapter 1 when defining terms. Briefly the main characteristics of these can be summarised as follows:

8.3.1 Formative evaluation

Formative evaluations aim to identify problems with resources and suggest appropriate solutions (Cronbach, 1982). Typically formative evaluation is conducted using a number of different tools which attempt to elicit from users of the system some type of rating for a variety of factors such as suitability and level of content, design and presentation, level of interest maintained etc. This is often done in conjunction with some form of observational measure. An important development in formative evaluation has been the emphasis which is being placed in more recent works on a more extensive dialogue with learners on their expectations and experience when using courseware. (Milne and Heath, 1998; Draper et al., 1995; Harvey, 1999)

8.3.2 Illuminative evaluations

Illuminative evaluations aim to discover the factors and issues that are important to the participants, instead of assessing the improvement in student performance when measured against how well the student can perform a particular task after being exposed to the 'educational intervention'. (These tasks are normally based on standard performance measures or assessment instruments employed in course delivery.) The focus of illuminative evaluation can therefore be said to be concerned primarily with how an educational intervention works rather than the outcome of the intervention. Although originally intended to replace experimental evaluations which were rigorously quantitative in approach (Parlett & Hamilton, 1987), it is now generally acknowledged that the two methods need to be used in conjunction in order to provide a clearer explanation of observed changes in performance.

8.3.3 Integrative evaluations

Integrative evaluations are closely related to illuminative evaluations but they focus more on attempting to identify and explain problems in learning situations, since such explanations may offer opportunities to integrate CAL more effectively. The environment in which the courseware has been introduced and the contextual issues which explain any reported 'learning effects' are thus the primary concern of integrative evaluation studies. It has been argued that integrative evaluation provides the kind of feedback that those who wish to use CAL are really seeking - not properties of CAL *per se*, but the delivery of effective learning and teaching using CAL (Draper et al., 1996). Draper's comment may be apt when looking at evaluation from the perspective of the teacher or lecturer who wishes to adopt CAL as an approach. However, it is open to question how convincing the integrative approach is to funders and adminstrators who are seeking evaluation which provides 'evidence' of some quantifiable change in performance. Moreover, there is evidence of some rather muddled thinking with respect to exactly how integrative evaluation provides this objective. Oliver, for example, notes that:

> *The aim of integrative evaluations is to lead to the emergence of a new role for the courseware being evaluated. They aim to improve teaching and learning*

by integrating CAL material into the overall situation more effectively. (Oliver, 1999).

The above quotation does not really describe a process of evaluation and verges towards providing a justification for the implementation of CAL rather than attempting to critically assess its value.

8.3.4 Summative evaluation

Summative evaluations aim to investigate how successful a resource is in terms of meeting its stated aims and objectives. This can be approached in a very blunt quantitative manner in order to demonstrate learning gains accrued as a result of using the resource. Much more often, however, it is moderated by an investigation of how the resource has been used and is often conducted in order to investigate a single well-defined question (Cronbach, 1982). Although this approach focuses on learning outcomes, these will need to take account of the context, as well as the educational technology which has been adopted. As a result, summative studies have been criticised for proving useful only in learning situations which closely resemble the evaluation.

8.3.5 Cost benefit/effectiveness analysis

As was noted in Chapter Six the evaluation of benefit in terms of cost effectiveness is an important theme when considering the social and political imperatives which have contributed to issues of transferability of courseware and the potential of multimedia CAL packages to supplement or replace expensive alternatives to teaching large cohorts of students. As noted previously, this is an area of concern which has until fairly recently been largely neglected by evaluation studies – even where an explicit objective of implementing CAL has been in order to achieve some efficiency gain in teaching a particular subject area.

It has been argued that it is only when used collectively that these various forms of evaluation can provide an accurate picture of the value of particular multimedia CAL packages and of the validity of using CAL courseware in general. They will provide evidence not only about performance changes which can be attributed directly to the use of a particular package but also on how the package effects changes in the way students learn and any environmental considerations which impinge on the change in performance which has been observed and which may in part explain them. All of these considerations are important if we are to be able to establish a benchmark standard for comparison of different CAL packages or for measuring the success of CAL against 'traditional' forms of delivery of higher education. However, whether it is necessary to view illuminative and integrative evaluations as approaches which merit being considered to be distinct evaluation strategies in their own right is open to question.

Prior to a full discussion of the manner in which these different types of evaluation have been incorporated into methodologies for conducting evaluation it is worth noting that essentially the 'traditional' division between formative and summative evaluation is still the main focus for most studies. As Harvey notes at the outset of the LTDI Evaluation Cookbook:

> *When the cook tastes the soup, it is formative evaluation; when the dinner guest tastes the soup, it is summative evaluation.*
> *(Harvey, 1999)*

The basic twofold purpose of evaluation remains focussed on:

- assisting in the systems development process (formative);

and

- determining the effects of a particular educational intervention on the process being studied (summative).

This does not however mean that concerns related to deriving a better understanding of the manner in which students interact with the courseware or the context of its use have been ignored. An examination of the different types of evaluation proposed above with reference to the purpose of evaluation clearly indicates that integrative evaluation can be viewed conceptually as a subset of formative evaluation which can prescribe the context in which the courseware has been 'successful'. Likewise illuminative evaluation can be seen as an extension of both formative and summative evaluation in that it can provide greater insights into the mechanisms by which an educational intervention achieves the results reported in the summative evaluation.

8.4 Formative Evaluation Procedures

As the use of computer based learning proliferated in the 1970s and 1980s there was a growing tendency in the literature to attempt to identify a means by which such packages could be evaluated (Bright, 1983; Cohen, 1983). Many of these concerns were not directly related to the evaluation of the outcomes of using CAL (indeed, as has already been noted, in some papers there is an implicit assumption that this has already been 'proven') but were geared towards the need to develop better methodologies for creating CAL courseware. Throughout the 1980s courseware packages tended to be developed in a pragmatic fashion and were often based on a 'cottage industry' approach – often based on the producer's own view of what constituted good instructional design. Development of standards was initially difficult because there was a wide range of opinion on what the 'ideal' was for courseware design. Furthermore some of the suggested criteria were developed with no empirical basis. For example, Roblyer in an article in 1981, recommended that an ideal team should be composed of two instructional designers, two subject matter experts and two technical experts. However, he provides no justification for this 'Noah's ark' approach and fails to acknowledge the fact that for different types of courseware a different approach may be more appropriate. (Roblyer, 1981)

Whilst there is some discussion as to the depth of formative evaluation required it is almost impossible to conceive of designing any form of teaching material without conducting formative evaluation in some manner - even if this is extremely informal. Alessi and Trollip (1991) provide an extensive discussion of methods of performing formative evaluations and numerous other authors have more recently provided a series of guidelines. (Riley, 1995; Barker, 1993; Brailsford and Davies, 1994)

One particularly useful aid in planning the formative evaluation for a CAL programme is provided by Kemp et al. who recommend that eight steps should be followed (Kemp, Morrison and Ross; 1994). These can be summarised as follows:

- Purpose – Why is the evaluation being conducted?
- Audience – Who are the target recipients of the evaluation?
- Issues – What are the main issues or questions which the evaluation seeks to measure or explore?

- Resources – What are the types of resource on which the evaluation will be based?
- Evidence – What type of information is provided in order to answer the questions or issues posed?
- Data gathering techniques. Consider how is data to be collected and how does this relate to the purpose of the evaluation?
- Analysis. Consider what techniques have been used for the evaluation of the data?
- Reporting. Consider in what format will the report be prepared?

For system developers the learning that goes on in an evaluation (whenever it takes place) may concern how their system could be changed to better fit the needs of the particular group for which the system has been developed but it can also be important in providing transferable information about design issues to increase the acceptance of the system by ensuring it is designed with user involvement. Used in this manner formative evaluation is also related to the iterative prototyping often advocated within the human-computer interaction (HCI) literature as being a way of improving a system as you go along, as well as empowering users by giving them a say on what their system will do (Nielsen 1993) and can at its most basic level be seen as concentrating on usability of the courseware. As Ramage notes:

> *There is nothing wrong in purely conducting a usability evaluation for formative purposes, but if one believes one has completely evaluated the system and its potential effects on an organisation in that way, unfortunate consequences could result.(Ramage, 1996)*

However, in many cases formative evaluation does not go much beyond usability questions yet there is an unfortunate tendency to speculate on effects on people and ways of learning which goes beyond the research data collected. An important exception to this general observation is the formative evaluation conducted specifically to address the question of investigating how students learn (illuminative evaluation).

Formative evaluation procedures are now fairly sophisticated and work done by McAteer and others (McAteer, 1997) typifies the current trend to expand formative evaluation so that it goes beyond asking simple questions which are directed specifically at how the computer system itself works and raises the question of how learners effectively interact with the system. The challenge for developers of courseware is to implement the procedures which have been advocated for formative evaluation in order to provide a much richer picture of how the courseware contributes to achieving its pedagogic objectives.

8.5 Summative Evaluation Procedures

We can distinguish between formative evaluation of the performance of a system and the more complex evaluation which takes place in order to establish that the system meets its objectives in terms of having a positive impact on learning outcomes. The main problem in the latter is associated with the definition of learning outcomes and determining the manner in which these can be measured.

In this respect the literature shows a difference in ideological standpoint typified by a quantitative versus qualitative debate (Miles et al. 1991; Flagg, 1990), different emphases on the stages of an evaluation (e.g. the relative importance of formative and summative evaluations) and different issues which are germane to the overall strategy adopted by the courseware and the objectives it sets for itself. The literature reviewed can be considered as falling into two main categories – the advocates of a rigorously quantitative approach to determining the manner in which 'learning effects' can be measured subsequent to the introduction of a new piece of courseware and those who advocate a qualitative approach to evaluation based often around measures which explain affective considerations of those involved in using the software.

8.5.1 Quantitative Studies

Historically, one could view the first introduction of a 'scientific' approach to evaluation in the work of Muller. In an attempt to establish some degree of control over subjective or invalid conclusions, Muller proposes that experimental approaches should be used to complement existing forms of software review as part of evaluation (Muller, 1985). He provided very detailed methods for measuring and evaluating learning outcomes but those were purely based on measures which may be applicable to the summative evaluation of tutorial or drill-and-practice software. Muller clearly recognised that controlling confounding variables in an educational setting is difficult, if not impossible and argued that:

> *the goal in educational research is to attain sufficient rigour in*

order to make the results scientifically acceptable, while at the same time making the results transferable to other educational settings (Muller, quoted in Oliver, Online)

This led Muller into an area of difficulty with respect to evaluation which is still very contentious i.e. the argument over the balance between control and authenticity. Muller's methods are selected based on a consideration of the degree of control possible for any given learning situation and his evaluation methodology obviously favours control over authenticity. In the simplest case, where the setting permits a control group to be established, a standard experimental design can be employed. The control group can either undertake some other activity or an alternative form of instruction during the intervention, depending on what kind of comparison is sought. Others however have questioned the ethics of this approach (Draper et al., 1994). Withholding a potentially useful source of learning from students cannot be justified – particularly if the evaluation is also designed to test an authentic situation and hence use of the resource could potentially help the student to perform better in a summative test or examination as part of his/her studies.

Likewise, in pursuit of a rigorously 'scientific' measure Muller contended that where randomisation or establishing a control group is impractical, pre- and post-test design can be adopted if each alternative explanation for improvement can be eliminated logically. Muller claims that greater confidence in results can be established with additional pre- and post-tests, used to give a long-term view of progress, and so highlight any long term impact the intervention may have. This, however, is highly questionable. Pre and post testing precludes designs where students have the opportunity to use alternative resources during the study, and it is not appropriate for long-term evaluations. (Newton et al., 1999). The post test should ideally be conducted as soon as possible after the learners have undertaken study using the CAL courseware being evaluated. If this is not the case there is potential for learners to acquire useful information and skills from sources other than the courseware being tested prior to the post test. As Draper points out, there is even the possibility that if the courseware has been poorly designed learners may 'autocompensate' for this and paradoxically a 'good' evaluation result may arise because the courseware was not fulfilling its learning objectives. Furthermore, as Foshay notes:

by far the biggest single factor influencing long term retention is whether the learner uses what's been learned in the interim ...(Foshay, 1992)

8.5.1.1 Meta-analyses

Muller's methodology was centred on the use of comparative evaluation based on pre and post testing to determine any observable changes in learning between two approaches. This is in fact a feature on which a number of studies have been based and it is therefore important to review the literature which concerns claims for benefits associated with CAL which are based on this approach. A number of studies have been produced which use a variety of different statistical approaches to attempt to demonstrate an 'improvement in learning' based on implementation of CAL courseware. The variety of approaches adopted to demonstrate this 'learning effect' and the varied amount of detail provided as the basis for reaching conclusions, however, makes an analysis of the literature on comparative studies very complex. Fortunately, a number of meta-analyses have been conducted which provide an analysis of a large number of such case studies. These meta-analyses (Khalili and Shashaani, 1994; Kulik, Kulik and Cohen, 1989) are often cited in support of the view that learning, in terms of the average performance score of students in tests using CAL, is better when information is presented in a CAL system rather than via traditional lectures. The meta-analytic approach used in the studies requires the reviewer to:

- Locate studies of an issue (using a variety of bibliographic search techniques to retrieve both published and unpublished works)
- Code the studies with respect to a variety of salient features e.g. type of application, duration of instruction, manner in which subjects were assigned in experimental and control groups, year of report and source of publication of results
- Code study outcomes using a common scale (to derive an effect size (ES) defined as the mean scores of the two groups divided by standard deviation of the control group)
- Use statistical methods to relate study features to outcomes

However, the findings of these meta-analyses are not convincing when the methodology by which they were conducted is examined in detail. For example, in the survey by Kulik, Kulik and Cohen noted above there are a number of inconsistencies in the findings for which no satisfactory explanation is put forward. The differential in learning effect was smaller when the same instructor was involved in both experimental groups and control groups in the comparison. This may well reflect on the fact that a comparison is being made between teaching methods which have had the benefit of considerable input from skilled educational instructors or which have been developed by staff who have considerable enthusiasm and have put much more effort into developing the teaching materials. (Bright, 1983; Clark; 1985). This fact has been stressed more recently by Laurillard who sees this as potentially a very important factor in determining the success of particular CAL implementations (Laurillard, 1994). It seems that what may be being compared is the instructor rather than the instructional method. In the same study there was a significant difference between the results which were sampled between those which were derived from published articles and those which were derived from unpublished papers and dissertations. The latter reports of experiments exhibited a significantly lower differential between experimental and control groups with respect to recorded learning effect scores. This is a very important finding and one which should lead the researchers to question the basis for claiming validity for the results which they present as the material on which the study is based appears to have an inherent weakness. Finally it is also noted that in shorter experiments which were used as the basis for analysis (conducted in full within one month) the improvement in learning was significantly higher than in experiments which were conducted over longer periods. This draws attention to the fact that the tests conducted to determine effect size were not standard throughout the studies which were compared. No account is given of how, or if, this difference was treated in statistical analysis of the results other than an oblique reference to the fact that different types of test employed in long term studies may explain the inconsistency noted above in short and long term exposure to computer assisted learning packages. Furthermore there is no detail on the instruments which were used to measure learning effects. This is a critical factor since if we are to claim anything more than shallow learning or ability to retain facts over a brief period the instruments and techniques used to determine learning effect must be sufficiently robust to measure such a change. This should imply a test which not only looks at simple responses to factual questions but also examines understanding and application of new knowledge. However, very often simple batteries of multiple choice questions (MCQs), generally administered immediately after the student has completed a particular piece of courseware, have been the sole instrument used to determine learning effect.

The meta-analyses also claim to support the view that computer assisted learning shortens the time taken to achieve similar or better educational performances. In an updated analysis of the survey quoted above (Kulik and Kulik,1991), a reduction in average learning time is recorded as a 36% saving (representing a reduction in classroom instruction from 3.5 hours to 2.25 hours per week). The main problems with such surveys is a lack of consistency over how computer based instruction is defined and a very simplistic interpretation of measurement of 'learning hours'.

Thus, for example, one such study recorded an 88% saving in learning time using computerized instruction (Kulik, Bangert and Williams, 1983). It is important to note, however, that this was in the context of computer simulations being used in a course in physics to replace lengthy laboratory sessions. In the same survey, the extent to which the result is dependent specifically on the instructional medium used (interactive videodisc) and the subject being delivered is not considered in the meta-analysis. Likewise a similar survey (Kulik, Kulik and Schwalb, 1986) identifies in one study a saving of 71% in using computer assisted learning as opposed to traditional classroom instruction but fails to explore a potential link between the student population being surveyed (in this case adult learners) and the outcome of the study.

8.5.1.2 Problems with quantitative approaches

Problems with the application of a quantitative approach are also evident with respect to individual studies. Phelps and Reynolds report on the pre and post test scoring which was conducted as part of the EuroMET project – a collaborative European project to deliver multimedia CAL modules for students of meteorology. (Phelps and Reynold, 1998). Two large scale programmes were produced, one on Numerical Weather Prediction and another on Satellite Meteorology. Each course contains 70 modules. Only twelve modules for each course were evaluated using pre and post testing of students but in all cases the maximum number of participants was no more than five and on average it was three. The researchers report a percentage figure for average improvement which ranges from 0% (recorded for 4 modules) to 75%. There is no acknowledgement of the fact that by definition one would expect an improvement in test scores and interestingly there is no discussion of the implications of the fact that in 4 out of the 24 modules tested the courseware appeared to have no effect whatsoever on student learning. Nonetheless the authors confidently state that

> *'the results from the modules for which pre- and post- tests have been undertaken are encouraging as they suggest that users are able to understand and retain information which helps them improve their level of knowledge' (Phelps and Reynolds, 1998).*

In a similar way the evaluation for CLEM (discussed in Chapter 7) shows a marked discrepancy in approach between what is being evaluated and the claims which are made for the courseware. The evaluation is a quantitative report on overall improvements of performance in student cohorts who used the material but does not address the crucial issue of explaining the differences which are noted in the evaluation report between the different cohorts who were involved. (Boyle, 1994).

Thus the confidence which is evident in many of the studies on computer assisted learning is not echoed uniformly. There are a number of authors who have been critical of both the methodology and the validity of the findings of such studies. (Clark, 1985; Dence, 1980; Leiblum, 1982). As Clark noted:

> *In meta-analyses of hundreds of CBI studies, there is clear evidence of consistent confounding in the research" (Clark, 1985)*

and the examples of studies quoted above certainly appear to indicate that the approach taken to evaluating CAL interventions is perhaps inappropriate. Selwyn's comments which are directed mainly at a consideration of research into IT applications in schools are just as apposite when considering the higher education sector when he comments that:

> *Research into IT in education has also suffered from an over-concentration on quantitative descriptive methodologies. Throughout the literature there has been a continued methodological preference for either the large scale survey or the more descriptive case study of technological implementation in schools. Although a crucial part of any academic field of inquiry, over-reliance on this tradition of research is a very limiting perspective to adopt regarding the role of technology in education. (Selwyn, 1997)*

The findings of surveys which seek to compare traditional delivery with CAL delivery generally fail to consider other possible reasons for the results achieved. The most obvious of these is that the learning material may have to be structured and organized to specifically take account of the medium for delivery. The process of comparative evaluation pre-supposes that the objective of teaching has been clearly defined and because of the awareness of the need to do this it is likely that these objectives will be carefully considered and implemented as part of any CAL courseware development. However, we should sound a note of caution here. It can often be the case that the learning objectives that are being evaluated in a particular study of CAL may be influenced by the teaching medium and methodology. Many evaluations are comparisons of different forms of teaching (or educational interventions as they are termed by the TILT group) and sometimes the objectives themselves are framed with a specific teaching mode in mind.

Thus, for example, a common objective of learning with CAL materials is the development of student centred learning and in some studies it has been argued that the use of self study CAL materials itself is evidence of this activity. We must be very careful to avoid such circular arguments.

As Alessi and Trollip note:

> *If we were to chart out all the instructional topics, the wide variety of students and the many instructional situations, we would sometimes find the advantage for books, sometimes teachers, sometimes film or video, sometimes peer-tutoring, sometimes hands on field experience, sometimes listening to audiotape and sometimes computers. It should not be surprising that across these many studies which utilized a variety of topics, students and situations, there was little or no overall effect.' (Alessi and Trollip, 1991)*

The point is echoed more recently. When reporting on a survey in which 'virtual lectures' were constructed and delivered to a group of students to be used in their own time Smeaton concludes that:

> *'good attendance at our traditional lectures does not imply good performance in exams and vice versa and this is exactly the result we found with our virtual lectures' (Smeaton & Keogh, 1998)*

This highlights a significant problem which bedevils evaluation studies on computer assisted learning i.e. the focus on results in terms of overall performance of a group of students rather than on the factors which might explain differences in performance by individual students.

The use of broad comparisons based on overall 'learning effect' has now been effectively dismissed as a useful research tool by some practitioners. (Bates, 1981; Keane, 1991; Gunn, 1996). That is not to say, however, that it has been discarded (Smeaton's & Keogh's study referred to above, for example, was conducted in 1998). Evaluation must be based on some form of comparison – either with other learning environments or with some form of grade referenced criteria which establish the usefulness of the courseware in achieving benchmark performance in agreed standard educational objectives. The problem with the latter is that we do not currently have a clear set of benchmark standards. As Draper notes:

> *... the first developments to be made should, we feel, be to adopt an adequate model of the teaching and learning process as a whole, and to apply it as an organising principle for our studies, and for advice to teachers on designing and checking their teachng. We feel we have established the need for such a model, and presented a possible candidate [Laurillard's conversational framework]. Developing this approach is a priority. (Draper, 1994)*

However, the development of a model for teaching and learning is not enough. At best this allows us to develop a methodology which can be based around the presence or absence of key components in the teaching and learning process as defined in the model. However, it does not allow us to measure the quality of these components (in Laurillard's case the interactions between teacher and learner which support the teaching and learning process). Thus as Draper himself commented at the CAL '95 workshop 'Two sentences by the course tutor had more effect than hundreds of hours of design and development'. (Draper, 1995 quoted by Boyle, 1997). In this case Draper was referring to the context in which the course was being delivered (as a compulsory part of the curriculum); however, the same may be said also of the manner in which courseware is supplemented by supporting comments and guidance from staff involved in assisting students to use the material. This is a factor which the TILT group, in support of their argument for a careful examination of context, have noted as being very significant.

Thus comparative approaches are required but in making such comparisons it must be stressed that all potential factors which may account for differences in student performance or attitude to the courseware must be thoroughly explored.

8.5.2 Qualitative/Affective Studies

Deficiencies in quantitative approaches have led to a more rigorous questioning of methods for evaluating CAL both from the point of view of what is being measured and the instruments and techniques used to capture appropriate data to measure 'success'.

Examining the first of these issues in fact provides an important pointer to identifying the dilemma of evaluation. Evaluation is attempting to measure a change in terms of an educational benefit but this is an area in which we do not yet have a clear set of criteria for measuring the reference point or points from which we are making our comparison.

Some of the most important work in re-appraising the manner in which educational benefits can be measured has been associated with the work of the TILT project (Doughty et al. 1995). The TILT group casts doubt on the sense of using simple quantitative results in terms of changes in 'student performance' as the basis for conducting evaluations. The group has been working to develop a framework for evaluation which concentrates much more on the integration of CAL into courses and relies on qualitative measures based on student feedback rather than on quantitative measures based on learning effect. At the heart of this approach is the need to make very careful observations of the learning environment. Although not specifically advocated by the TILT framework (which is discussed below) the most influential work done in providing insights on how to conduct such observations is associated with the development of phenomenographic techniques and the educational research in this area conducted by Marton and others.

Phenomenography is a word which is derived from two Greek words "phainomenon" and "graphein" meaning "appearance" and "description" respectively. Phenomenography grew out of phenomenology which as a branch of philosophical studies has a long tradition. Descartes' separation of the thinking mind from the material world of things and objects (encapsulated in his famous dictum '*cogito ergo sum*') was the cornerstone of much subsequent philosophical enquiry which called into question the assumption of one determinable, objective reality. Husserl was the first writer to explicitly identify phenomenology as a branch of philosophy and his premise was that it is possible to examine the world without any preconceived notions about causes or underlying structures. Phenomenologists thus reject the acceptance of unobservable matters and grand systems which are erected as the result of speculative thinking. Careful exploration of observable data (i.e. the data available to conscious experience) makes it possible to arrive at an explanation of all phenomena. In the realms of psychology the same approach applied to investigating the construction of knowledge led Jung to identify 'observable' components of knowledge: sensing, thinking, feeling and intuition. This typology influenced a number of psychological tests – notably the Myers-Briggs Indicator and other learning styles instruments (including the Gregorc Learning Style Delineator).

As noted above, the use of principles derived from phenomenology in order to conduct research is associated primarily with the work of Marton who defines phenomenography as :

> *"the empirical study of the limited number of qualitatively different ways in which we experience, conceptualize, understand, perceive, apprehend etc. various phenomena in and aspects of the world around us". (Marton, 1991)*

Furthermore, Marton sees the role of phenomenographic research as being to:

> *"identify and describe conceptions of reality as faithfully as possible ... the more faithful we can be to conceptions of an aspect of reality the better we are able to understand learning, teaching and other kinds of human action (Marton, 1993).*

The practical application of this approach in an educational setting is illustrated by the work carried out by Marton and others at the University of Goteborg in Sweden in the 1970s. (Marton, 1993). This work was concerned with investigating what is meant by the statement that 'some people are better at learning than others' . In order to be able to begin to answer this question it was necessary to research the manner in which learners approach a particular task and this was done by studying learning under comparatively natural conditions and approaching the study from the perspective of the learner. The results of experiments conducted involving comprehension in reading texts suggested that there were a limited number of different ways of understanding the text. By isolating these categories it was possible to conclude from the experiment that the important factor in determining why some people are better at learning than others was that people differ in their approach to learning tasks (Marton , 1993) and the more effective approaches could be identified. This was shown by a phenomenographic approach which simply observed the experience of individuals in conducting the task without pre-judging any 'ideal' mechanisms of achieving the task. Further research conducted using phenomenographic methods suggested that this conclusion was valid across a range of learning activities – essay writing (Hounsell, 1984), attention in lectures (Hodgson, 1984) and problem solving (Laurillard, 1984). They also confirmed a recurring principle in the use of phenomenographic research methods, i.e. that whatever phenomenon or situation people encounter, a limited number of qualitatively different and logically inter-related ways in which the phenomenon or situation is experienced or understood can be identified. Phenomenographic methods, thus, shifted the focus of research in education away from specific learning situations and outcomes and towards learners' preconceived ideas about the phenomena being dealt with and the general approach of learners to an instructional task.

8.6 Frameworks for Evaluation

It is in attempting to resolve the issue of the extent to which quantitative or qualitative techniques are required and the balance in which they should be applied that a number of frameworks for evaluation of CAL have been put forward. These vary not only in the extent to which they rely on quantitative or qualitative measures but also in the different emphasis placed on the circumstances in which the evaluation should be conducted, data collection tools and techniques used for interpreting results. The following section examines the development of some frameworks which have been put forward for CAL evaluation.

8.6.1 Hybrid Evaluation

Generally, whilst there is a tendency in recent literature to emphasize the qualitative approach, it is now recognised that evaluation needs to encompass both quantitative and qualitative measures. Atkins was one of the first authors to specifically propose a hybrid style of evaluation, using both qualitative and quantitative techniques to complement each other and increase confidence in results. (Atkins, 1988) Atkins proposed the use of questionnaires and semi-structured interviews to gather data. Whilst the ordinal data provided in questionnaires is analysed quantitatively, qualitative responses are analysed using a variant of grounded theorising (Strauss, 1987). Responses to each question are coded, using categories suggested by the data. This process is repeated until all data have been categorised and a complete set of categories has been established. Categories are thus collectively exhaustive (i.e. all data from answers to evaluation questions are assigned to categories) and exclusive (i.e. no two categories in the analysis are the same). In order to ensure that data is coded objectively categories are established on the basis of what was said or recorded on questionnaires rather than its latent meaning[1]. Further, in order to ensure objectivity Atkins advocated the use of external evaluators (he uses the term researchers). In purely quantitative analyses the evaluators would work by conducting a battery of standard tests on statistical data. In contrast the outcome of the coding process to identify categories meant that evaluators could make use of techniques such as concept mapping to derive overarching theories grounded in the data (Strauss, 1987).

Atkins methodology has had a considerable influence on directing evaluators to re-assess the validity of basing evaluation on conclusions derived from quantitative analysis of responses to questions which inevitably reflect the evaluator's predisposition to a particular view of the important factors which have influenced the use of courseware. Instead the focus is on themes which emerge from the evaluation process itself.

8.6.2 Laurillard and Kerry

As noted in Chapter Six Laurillard's conversational framework (1993) is not in itself a formal framework for evaluation but forms the basis of evaluative methodologies which concentrate on investigating what takes place during the learning process. Several authors (notably Draper, 1994) have used Laurillard's model in order to establish a framework for evaluation in which the emphasis is on observing and measuring the interactions which occur during learning. Typically observations, interviews and tracking of performance (including written protocols, program inputs, dialogue, etc.) are conducted.

A distinctive feature of the manner in which Laurillard herself framed the conduct of an evaluation was to emphasise the importance of gathering data in retrospect. (Laurillard, 1993). Thus for example she advised against the use of intrusive meta-level observations such as 'think-aloud' protocols. She considered that these could change the processes which were being observed and thus reduce the validity of the evaluation. It was similar concerns which had prompted the development of Kerry's model which relied on 'self-report' case-studies, compiled by teachers in order to determine the efficacy of introducing CAL courseware (Kerry, 1988). However, in Laurillard's case the focus for evaluation of CAL is very much on the learner rather than the teacher.

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[1] *Reeves adopts a similar stance in developing instruments for capturing data. His instruction to use an 'anecdotal record form' echoes a concern for ensuring that what is recorded is not subject to interpretation which may reflect a particular bias on the part of the evaluator.*

In both cases analysis and data collection is done in two phases. The first phase covers the learning session, and involves the examination of data collected from observation work and logs of activity. The second phase makes use of this data to prompt and guide students' (or teachers') explanations during follow-up interviews.

8.6.3 The Open University Model

The evaluation of courseware in the Open University provides a useful practical framework and focuses on three main themes: context, interaction and outcomes. (Jones et al, 1996).

A variety of methods of data collection are used, including questionnaires (both postal and on-line) interviews with staff and students which focus on particular issues and problems, post-course questionnaires, and logs of computer use. Rather than rely purely on automatic tracking or computer generated reports of time spent on particular tasks, questionnaires are used in conjunction with this to elicit data on patterns of use of the courseware. Collectively these are analysed to provide a complete picture of the context in which the courseware is being assessed and the interaction which students *have had with the* courseware. This can then be used to provide a more accurate interpretation of the data collected and *supplementary follow-up* interviews are conducted in order to ensure that results are consistent.

In the Open University model (in contrast to Atkin's framework) the input of practitioners is considered crucial when designing evaluation tools, assessing responses, and interpreting findings. (Jones et al., 1996).

As reported by Oliver and Conole (1995) the framework is presented as a grid in which these themes are matched against the rationale for evaluation, data to be collected and methods used to collect data. This is a useful model which was particularly influential in the present research in developing an evaluation matrix on which a framework for evaluation strategies could be developed.

8.6.4 The TILT framework

The TILT group was set up as part of TLTP and the section of TILT which is most clearly concerned with evaluation issues is based within the Department of Psychology at University of Glasgow. The group aims to carry out evaluations, use this experience to provide guidelines, and to provide training in evaluation strategies which will allow teachers to perform effective evaluations independently. By 1997 the group had carried out more than twenty extensive evaluations which covered a variety of subject areas within Glasgow University and in the course of doing so have developed a distinctive approach to evaluation. The TILT project's framework is derived from the illuminative approach to evaluation (Draper et al., 1994; Draper et al., 1996; Draper, 1997). It aims to evaluate the course as a whole, rather than simply the resource being used, and aims to improve learning by integrating educational technology as effectively as possible into the learning environment. Draper argues for the need for some form of framework to support the evaluation of learning and Laurillard's conversational framework is adopted as a model for student-teacher interactions, allowing the framework to focus on educational interactions. Adopting an illuminative approach in its strictest form all but precludes comparative or experimental research designs based on an examination of 'learning effects'. However, the approach has the advantage of deriving detailed data about the manner in which courseware is used by learners and their perception of its usefulness. This enables a wider range of explanations to be offered, and allows some results to be generalised (Draper et al., 1994).

In addition an increasingly important theme which is being developed by the TILT project team is to develop the use of 'authentic' course assessments. Indeed in more recent output from the group TILT's framework can be seen to be predicated on the assumption that the evaluation must take place in context, (cf for example the SECAL (Situated Evaluation of CAL) framework which is described below – Section 8.5.3.5) since it aims to evaluate the course's use of educational technology, not the educational technology alone.

This concern is also evident in the approach taken by the TILT group to ensuring validity of results. It is argued that only in-course evaluations can be assured of validity, since other research designs are unable to match the conceptual and motivational factors which influence learning. Motivationally, most students only learn material because it is a course requirement that they do so. The move towards an assessment driven pattern of course delivery was also noted by

Newton et al (Newton et al., 1999). Thus it is argued that the situation in which the courseware is tested must be genuine and students must feel a degree of compulsion to use the courseware in order to achieve and pass the objectives set for the course as a whole. This therefore precludes the use of volunteers instead of students on a course (adopted, for example, by Ross, 1997). (Draper et al., 1996). The framework, like the Open University framework, seeks to involve practitioners as part of the evaluation process and indeed their exclusion in 'classroom based evaluations' would be almost inconceivable. The framework involves both staff and students, and occurs in two phases. The "outer method", involving staff and evaluators, generates the design of an "inner method", which details how a selection of evaluative instruments and observation methods are to be used (Draper et al., 1996).

Evaluation instruments are selected on the basis of utility, within practical constraints such as evaluators' time limits and student tolerance for giving data. Tools such as questionnaires are often used, since these are easy to administer and quick to complete. These are supplemented by personal observations and interviews. A range of 'standard' evaluation tools have been developed as part of the TILT project, although few studies which they themselves have conducted use all of these. Such tools (some of which have been used in the empirical study described in Part Two of the thesis) include:

- Computer experience and confidence questionnaires;
- Student profiles, recording which courses each student has taken;
- Logs of students' confidence on a list of learning outcomes. These are used prior to and after each intervention;
- Knowledge quizzes, used for pre-, post- and delayed post-tests, usually in multiple choice format for consistent marking. Each question corresponds to a distinct learning objective. (It is suggested that low post-test scores may indicate that an objective needs different treatment while high pre-test scores may indicate that content is redundant);
- Post task questionnaire. This investigates what students felt they were doing during the learning task, and why. It can also involve specific questions such whether a glossary was useful, whether the content was relevant to the course, etc.
- Focus groups and interviews. These allow a check on the quality of the written responses and are used as an open-ended instrument to elicit points unforeseen when the questionnaires were designed.

Doughty sums up the significance of the TILT group's approach to evaluation as follows:

> *One of the most important outcomes of TILT has been in establishing how to help teachers with the formative evaluation of their teaching. Our efforts suggest that even when studies were originally seen as summative evaluations of software, the main benefit [of the evaluation] is in helping teachers, as course managers. There remain problems with the evaluation instruments, with some data being particularly difficult to interpret. Attitudinal measures, for example, seem to express how a learning experience compared with a student's expectations. Even changes of attitude are difficult to interpret; no shift at all would indicate that their expectations had been accurate, but would not indicate what those expectations had been. Similarly, confidence logs clearly cannot adjust to the situation in which the courseware is used in order to maximise the benefits to students. In other words such evaluations take the role of formative evaluations of the wider teaching situation within which the software plays a part. (Doughty et al. 1995)*

Like all evaluation frameworks, however, a critical problem which has not yet been fully resolved concerns the validity of the instruments being used. In particular this is a problem for tools which attempt to provide attitudinal measures. The use of a variety of different methods, however, assists the evaluator to be more confident that any learning gain or change in attitude can be attributed appropriately to the courseware itself. In this respect open-ended measures and observations are particularly important. As Draper notes these can be particularly important in explaining results which are not predicted or which appear to be contradictory (Draper et al., 1996).

8.6.5 SECAL and Legenhausen's CALL framework

The Situated Evaluation of CAL (SECAL) framework (Gunn, 1997) probably goes further than any other framework in advocating the use of 'genuine contexts'. Indeed it could be argued that the SECAL framework attempts not only to provide evaluation *in context* but also provides an evaluation *of context*. It considers the primary effects of CAL use in terms of learning outcomes and perceptions of learners regarding the value of the courseware and it also attempts to examine factors which influence the integration of courseware within the learning environment and thus explain the results of the evaluation with reference to the very specific context in which it was introduced. Gunn argues that all factors must be taken into account when conducting an evaluation and that it is wrong to attempt to focus exclusively on one particular aspect or factor in the learning situation. As a consequence case study type work is a feature of SECAL evaluations. Obviously authentic learning situations are a pre-requisite for performing such evaluations. The description provided by Gunn of the SECAL framework is very akin to descriptions of action research although the parallel is not explicitly drawn. (It is interesting to note that the TILT group are also giving more prominence to the use of action research type methodologies). In particular it is advocated that researchers should be free to follow up particular lines of investigation suggested to them by observation of the learners and change conditions to test reactions of the learners and not be constrained to following a rigid methodology. Realistically this type of framework can only be applied when dealing with very small sample sizes.

Similarly a framework for evaluation of Computer Assisted Language Learning (CALL) evaluation has been proposed by Legenhausen and Wolff (1990). Again the approach stresses the importance of context, and of involving practitioners in study design and data interpretation. Unlike SECAL, however, and perhaps reflecting the more objectively measurable outputs of programmes of language study, the approach uses qualitative data but applies a rigorously quantitative approach to evaluating success from the point of view of changes in knowledge and understanding of students who participate in using CALL software.

8.6.6 Holistic evaluations

Finally, prompted by the deficiencies of comparative evaluations Mason has argued that much broader institutional effects and contexts must be taken into account when evaluating CAL. (Mason, 1992). Because the introduction of new technology often alters the nature of learning outcomes, rather than the quantity of what is learnt, it is argued that methodologies which focus on learning gains alone often find no benefits to CAL use. Mason thus argues for an evaluation framework which examines the changed perceptions of the users e.g. changes in motivation to study, changes in the economics of delivery or changes in the 'attractiveness' of particular courses to students. However, while she argues that such changes can be measured fairly simply using data which is readily available e.g. student drop out rates or course application statistics, it is very doubtful whether a clear causal relationship between changes in such general measures and the application and use of CAL is tenable.

8.7 Evaluation Matrix and Framework

The problem with many of the proposed models for evaluation of CAL is not in the techniques for collecting data nor in the manner in which the data is analysed. The problem lies rather in the lack of clear definition or purpose of evaluation. A number of authors have pointed out that the main problem which besets evaluation of the use of new technology in higher education is the fact that the focus for evaluation is often not clearly defined. (Ehrmann, 1995; Draper, 1994). As Ehrmann notes:

> *It takes just as much effort to answer a useless question as a useful one. The quest for useful information about technology has to begin, then, with thought about just what are the right questions' (Ehrmann, 1995)*

Similarly when evaluations are inconclusive it is often the case that an inappropriate evaluation design was used, and the desired result could not have emerged from the evaluation. (Foshay, 1992). This is certainly borne out by an examination of a number of 'evaluation' studies reported in the literature.

Whilst it has already been noted that this is a theme which has been stressed by a number of authors, the context in which this is discussed is often aimed at providing a general justification for conducting evaluation. The starting point for finding the 'right question' must be to consider critically the purpose for which any particular instance of CAL courseware has been developed or is being used. It is only when this is clearly defined that it is then possible to develop a suitable evaluation strategy. With a clearly defined objective stating what the courseware is meant to achieve it is then possible to state the basic principles which should underline what the evaluation must achieve. The purpose of evaluation thus must be approached on a case by case basis and framed in terms of providing a clear correlation between the objectives of the courseware being studied and the outcomes of using that courseware. This will then allow a more informed approach to selecting suitable measures which should be employed in order to provide a viable evaluation of whether these objectives have been met *within the context of the rationale for developing and/or using CAL.*

8.7.1 Evaluation Matrix

The basis for a proposed framework for evaluating these factors is presented as an evaluation matrix in which development, formative and summative evaluation are seen to have particular roles in contributing to the overall assessment of the courseware. The matrix is based on the Open University framework but examines rationale for evaluation, data required and collection methods in conjunction with the stages of evaluation rather than in terms of context, interactions and outcomes. The matrix (Figure 8.1) highlights the importance of determining clearly the educational objectives of the courseware (development stage), assessing student interaction with the courseware and the robustness of the courseware (formative evaluation stage) and adopting suitable instruments to measure the outcome of use of the courseware (summative evaluation stage). The roles proposed by the TILT group for integrative and illuminative evaluation are subsumed into the parts of the framework which deal with the formation of educational objectives and user interactions which are explored during formative evaluation. The matrix follows the Open University framework closely in suggesting the data which must be collected at each stage of evaluation of the courseware. Possible data collection methods and appropriate analytical treatment of data are not discussed in detail as there is ample literature to guide a potential evaluation in this respect. A good starting point for this would be the LTDI's Evaluation Cookbook (Harvey, 1999) but there are numerous other detailed studies on conduct of observation, use of questionnaires, focus group techniques etc.

The matrix also incorporates features from other evaluation frameworks which have been discussed in this chapter. For example, Mason's suggestion for developing holistic evaluation by examining broader institutional sources of data is incorporated as a means of performing summative evaluation as part of measurement of long term impact of use of CAL. Significantly quantitative measures are not discarded but are highlighted as a potentially important part of the summative evaluation stage.

It should be emphasized that the matrix provides only the basic structure which ties together the developmental and evaluation stages and seeks to give general guidance on what is required at each stage and how this information can be gathered. As such it provides a useful starting point for a framework for evaluation but more specific information is required on the manner in which factors influencing the evaluation must be dealt with in terms of developing an evaluation strategy.

	Educational Objectives (Development Stage)	***User Interaction and Acceptance (Formative Evaluation Stage)***	***Learning Outcomes (Summative Evaluation Stage)***
Purpose	Evaluation of CAL must be framed in the context of what CAL was intended to achieve.	Ensure system performs according to specification but in addition it is important to examine interactions between the system and the user in order to focus on the learning process	Learning outcomes and/or affective outcomes (perception or attitude) must be considered when evaluating courseware
Data which must be collected	A clear statement of aims, and objectives of CAL and the context in which it is designed to be used	Feedback from learners Learner Profiles	Evidence of: • Quantitative changes in delivery costs • Quantitative changes in knowledge/cognitive skills • Qualitative changes in attitudes • Long term impact of learning
Possible data collection/analysis methods	Analysis of policy documents Interviews with CAL developers. Analysis of published output	• Questionnaires to elicit demographic data • Learning Style Inventories • Observation • Online tracking of actions • Confidence logs • 'Think aloud' protocols • Focus groups	• Costing models for educational delivery • Standard tests and quizzes delivered pre and post use of courseware or comparative success of paired groups • Attitudinal questionnaires administered pre and post use of courseware • Performance criteria for course delivery and completion e.g. student success ratios, student wastage, course evaluation questionnaires

Figure 8.1 Evaluation Matrix (based on the Open University framework for evaluation) (Jones et al., 1996)

8.7.2 Proposed Evaluation Framework

Specifically, therefore, a full framework for evaluation must acknowledge the importance of:

- stating clearly the pedagogic objectives of developing and using the courseware;
- detailing of the intended audience and in particular any pre-defined objective with respect to the manner in which the courseware caters for individual learners or seeks to develop or strengthen learners' predisposition to interact with the courseware and hence benefit their 'learning experience';

and

- outlining the institutional context in which courseware has been developed and is to be delivered.

These will all have a major influence on the type of evaluation which must be conducted because they collectively provide data which informs us of the purpose and context in which the courseware was developed and the intended outcomes of using the courseware. This will then have a direct impact on the hypotheses or research questions that need to be addressed and hence influence the evaluation strategy that must be employed. Figure 8.2 summarises the main determining factors under three headings which equate to the bulleted points made above. The figure also relates these factors to the parts of the thesis in which they have been discussed.

With respect to pedagogy the major influencing factor will be the overall approach being adopted by the courseware. As noted in preceding chapters there are a number of design factors which are recommended when designing learning environments to support different pedagogical approaches and a number of claims made relating to the particular skills which are acquired by students as a result of this. The more sophisticated (and expensive) techniques are generally required in order to implement constructivist environments and these claim to support the development of very high level skills and foster a 'deep approach' to learning. In addition it is important to be clear about whether the overall objective of introducing the courseware is to develop particular subject specific skills or whether an additional or alternative impetus to developing and using the courseware is to develop key generic and transferable skills.

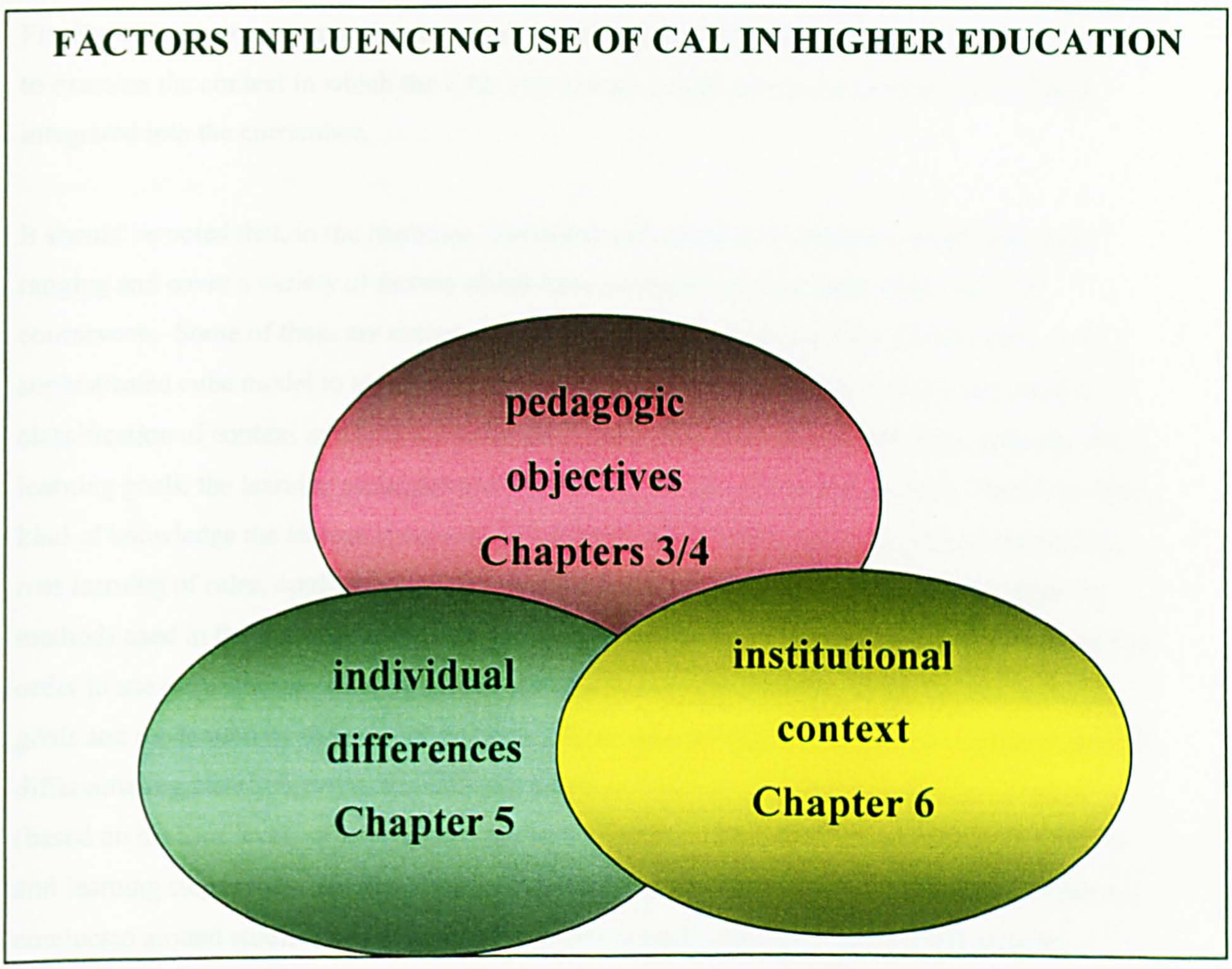


Figure 8.2 Factors influencing use of CAL in Higher Education

With respect to intended audience it is important to be clear about the learner population which the courseware is designed for. At one level this is important in ensuring that the courseware is evaluated in an appropriate context, as obviously it is not appropriate to evaluate a piece of courseware which has been created for use with a group of students against its performance when used with a group of students who do not exhibit the same background level of expertise in the subject, level of maturity or motivation to use the courseware. At another level it is important to recognise the fact that students may exhibit significant differences in their approach to using the courseware. Thus evaluation must ensure that any overall learning effects are not confined to particular groups of learners who have a predisposition or possess skills which allow them to use the courseware more effectively.

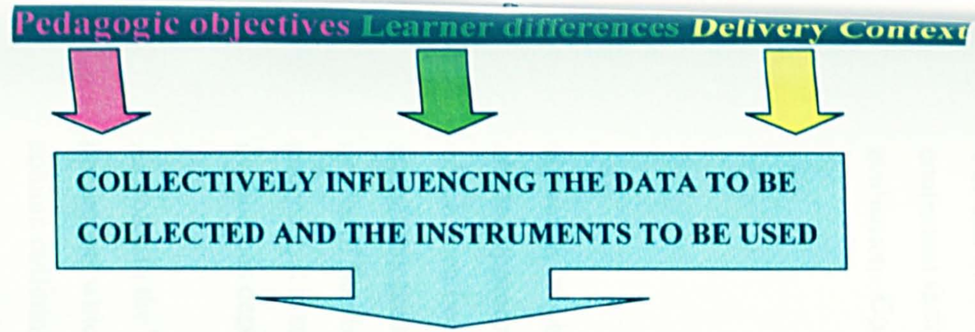
Finally with respect to institutional context in which the courseware is being used it is important to examine the context in which the CAL courseware is implemented and how CAL is being integrated into the curriculum.

It should be noted that, in the literature, discussion of context of evaluation can be very wide ranging and cover a variety of factors which have an impact on user interaction with the courseware. Some of these are extremely complex. Baumgartner and Payr (1994) use a sophisticated cube model to classify learning software which actually provides a very useful classification of context in which the software is used. The three axes of the cube represent the learning goals, the learning strategies and the learning levels. The learning goals determine what kind of knowledge the learner is supposed to acquire (e.g. problem solving, pattern recognition, rote learning of rules, application of rules in context etc). The learning strategies describe the methods used in the software for teaching. The learning levels describe the capabilities needed in order to use the software. Learning strategies are thus determined very much by the learning goals and moderated by the level of learning. Romiszowski draws attention to the importance of differentiating clearly between the different levels at which an evaluation should be targeted (based on his four levels of implementation which are project level, curriculum level, unit level and learning step level). An important point to make in this respect is that evaluations which are conducted around studies based at one level should not necessarily be interpreted as being directly transferable to other levels. Thus Draper notes a number of cases 'niche based' success in CAL implementation and ascribes 'success' to the very focussed approach which has been taken in a particular 'problem area' in curriculum delivery for which courseware has provided a solution. The arguments from such cases, however, cannot be generalised to implementation of CAL in more general settings. In addition there are course other important factors which relate to the teaching environment generally. Barnard and Sandberg (1995) provide a discussion of context based on what they term "the learners' socio-cultural niche", by which they understand the whole environment in which the learning is delivered: the learning model, the learning tools (both of which are discussed here in terms of pedagogic approach), access to external information sources and the manner in which interaction with other learners and tutors is facilitated.

In terms of developing the evaluation framework presented here, context is seen as an issue which centres around the delivery of the CAL courseware. Specifically the framework stresses the importance of being clear on whether the courseware is being developed in order to improve the quality of learning or to improve the effectiveness of delivery. This may often be reflected in whether the courseware is intended as an additional resource (often provided as an open learning resource) which is designed to supplement 'traditional teaching' or whether the courseware has been designed to replace all or parts of a course of study. If the courseware has been developed to replace a part or the whole of a course then it is imperative that all learners are supported equally and that this is an important factor in planning the evaluation strategy. Related to this point (though not necessarily always specifically associated) is the question of whether the resource has been developed or is being used because of potential cost savings. This is often the argument for developing courseware that is designed to replace traditional teaching. If this is the case then it is obviously important that any evaluation of the resource must make such cost savings explicit. As noted in Chapter Six, issues of cost-effectiveness may be extremely important and if these have been the driving force for creating and using the courseware being evaluated. In such cases it is imperative that the evaluation strategy adopted makes very explicit reference to costs and provides detailed evidence to demonstrate whether this objective has been met. Contextual issues clearly will have an important affective impact on users of the courseware and on the expectation of the learning outcomes derived from its use. This implies that this should have an impact on the evaluation strategy which should be adopted, but this is not always made clear in the literature.

Thus when developing and using multimedia CAL in Higher Education it is proposed that it is necessary for an holistic evaluation framework to take into account a range of factors which impact on the outcome of introducing a new piece of courseware. Figure 8.3 provides a diagrammatic representation of the complete evaluation framework and the following commentary discusses the major considerations which impact on the framework as a result of these factors.

The framework is presented as a grid which represents the main steps in development, formative and summative evaluation. The contexual factors which impinge on formative and summative evaluation procedures are shown above the grid to demonstrate that these are overarching factors which will influence the evaluation strategy to be adopted. In developing an evaluation strategy there are certain procedures in which the evaluator has an element of choice – either in terms of whether or not to undertake certain tasks or as to the choice of tools which need to be used. These areas are highlighted on the grid and have been numbered so that, in the discussion which follows and which concentrates on how contextual factors impinge on an evaluation, the different sections of the framework are easily referenced



	Educational Objectives (Development Stage)	***User Interaction and Acceptance (Formative Evaluation Stage)***	***Learning Outcomes (Summative Evaluation Stage)***
Purpose	Evaluation of CAL must be framed in the context of what CAL was intended to achieve.	Ensure system performs according to specification but in addition it is important to examine interactions between the system and the user in order to focus on the learning process	Learning outcomes and/or affective outcomes (perception or attitude) must be considered when evaluating courseware
Data which must be collected	A clear statement of aims, and objectives of CAL and the context in which it is designed to be used	Feedback from learners Learner Profiles	Evidence of: Quantitative changes in delivery costs Quantitative changes in knowledge/cognitive skills Qualitative changes in attitudes Long term impact of learning
Possible data collection/analysis methods	Analysis of policy documents Interviews with CAL developers. Analysis of published output	Questionnaires to elicit: demographic data Learning Style Inventories Observation Online tracking of actions Confidence logs 'Think aloud' protocols Focus groups	Costing models for educational delivery Standard tests and quizzes delivered pre and post use of courseware or comparative success of paired groups Attitudinal questionnaires administered pre and post use of courseware Performance criteria for course delivery and completion e.g. student success ratios, student wastage, student course evaluation data

Figure 8.3 Evaluation Framework

8.7.2.1 Impact of contextual factors

The aim of developing the CAL courseware has to be considered in terms of the different contextual factors discussed above and this will determine the data collection stage in the evaluation. Commenting on the general approach taken to evaluation Crompton notes that:

> *the degree of combination [of qualitative and quantitative approaches] will depend largely on a process of negotiation between the evaluator and the instigator of the evaluation as well as the argument and the time frame in which the evaluation is being performed (Crompton, 1996, p.66)*

However, it is important that pragmatic considerations are not allowed to drive evaluation studies and the approach taken in the evaluation framework outlined here is to provide a set of criteria which must be adhered to if the evaluation is to be valid. In this respect the evaluation framework presented here differs significantly from other frameworks in that, whilst there is a degree of flexibility over the tools used to collect data and the manner in which that data can be analysed, it is suggested that there are certain procedures which must be incorporated into evaluations dependent on the objectives for which the CAL courseware has been developed.

As noted in the framework the sources for collecting data to inform the evaluator would be the documents which were produced setting out the objectives of the courseware (cells within the column outlining the educational objectives). As implied in the structure of the framework, these are not optional considerations but must be determined for any evaluation. Unfortunately, it is sometimes the case that this data is not apparent in such documents. In order to elicit this information it is useful (for both developers and evaluators) to employ a checklist approach which encourages reflection on the purpose of the courseware and thus clarifies the purpose for which the courseware is intended prior to engaging in an evaluation. Useful checklists have been developed by a number of individuals. (Machell and Saunders,1991; Brown (in Draper et al., 1994); Tessmer and Harris,1992; Crompton,1996; Smith and Mayes, 1995) It should be noted that whilst some of these are termed 'evaluation checklists' their application at the point of development of courseware should be encouraged in order to ensure that the context in which the courseware is designed to be used (and hence evaluated) is clearly defined. A persistent problem in evaluation studies is that the questions being asked of the evaluation (e.g. is the system easy for students to access and use independently?, will using the courseware have cost savings in terms of contact time with students?, will the students 'learn better' using the courseware? etc.) may not be appropriate because the courseware was not developed in order to address these questions.

8.7.2.2 Institutional/Delivery Context

The issue of delivery and the aim of the courseware with respect to the intended outcomes for the manner in which teaching and learning is facilitated is the first thing which must be made very clear. Thus the first question which must be addressed in developing an appropriate evaluation strategy is to be clear on whether the primary objective of the courseware is:

1. To improve the quality of learning;
2. To make delivery of teaching more effective;

or

3. To achieve both these objectives

In practice the two different approaches may by associated respectively with the decision concerning whether the courseware implementation is intended to supplement or to replace existing teaching materials and/or methods.

As was noted in Chapter Six, the preponderance of literature to date has dealt with examining the evaluation of CAL from the perspective of improving the quality of learning. If this is the case in the evaluation being considered, then it is valid to work within a framework in which it is not necessary to consider any quantitative changes in delivery costs. (Frames 5 and 6 of the framework).

If the aim of development is to improve delivery efficiency then this factor cannot be ignored. From a practical point of view, however, such evaluations immediately run into serious problems for, as has been noted previously, this is an area in which the costing models to support any contentions made to provide evidence of having achieved this outcome are not yet developed. Until such models have been developed the implementation of this element in the evaluation framework will be problematic.

Notwithstanding this an important aspect of evaluations which are centred around the aim of improving the efficiency of delivery is an implicit qualification that in doing so the quality of learning does not deteriorate. It would be relatively easy, for example to devise a CAL based approach to learning and delivering a particular topic which proved to be very efficient in terms of resources but which had an adverse effect on learning[2]. In order to demonstrate that improvement in quality of learning has been achieved it is necessary to examine the learning outcomes (frame 4) and demonstrate a quantitative change in knowledge or cognitive skills (frame 5). The type of data that is required to demonstrate this will depend largely on the pedagogic objectives of the courseware and this is discussed fully below.

An important point to note at this point is that often a measure of quality is determined by eliciting feedback from learners (frame 2). This can be done by using one or more of the observational data collection techniques defined in frame 3 of the framework. However, within the framework these are used to inform the formative evaluation of the courseware. Such techniques tell us more about the mechanism by which learning took place (or failed to take place) and can be used to explain the results of the summative evaluation. Formative evaluations are important in evaluations of courseware but their main purpose must be seen to be as providing evidence which 'illuminates' our understanding of the learning process. This is particularly effective when such studies are integrated in an authentic learning situation.

Finally, in common with the reporting of any piece of research an evaluation study should clearly describe the context in which the experiment has been conducted (in this case the context in which the courseware has been used). As a minimum this has to be done in terms of a description of the hardware and software environment in which the courseware was tested, additional resources which were used, the learner population being tested, and the manner in which learners were supported.

8.7.2.3 Pedagogic Approach

The next step in developing the evaluation strategy is to be explicit about the overall approach that is being adopted in teaching. In this case the main question is to establish clearly the basic

[2] *Gordon Doughty in his e-mail response in the survey which was described in Chapter 7 actually quotes an instance of where this was the case and because of the consequent decline in student success the implementation of the courseware had to be radically re-considered.*

approach in terms of pedagogic objectives for the courseware. Broadly, whilst recognizing that courseware may provide tools to apply a combination of these approaches it is important to determine the overall pedagogic approach in terms of being:

1. Behaviourist;
2. Cognitivist;

or

3. Constructivist

Whilst parts of a piece of courseware may be designed in order to promote the development of higher cognitive skills, as has been noted in Chapter Seven, the bulk of courseware that has been developed for use in higher education adopts a markedly behaviourist approach to teaching (even in some cases where the courseware claims to be developing a more critical and reflective approach to learning and hence developing cognitive skills).

If the objective of the courseware is to focus on behavioural outcomes then an approach that uses quantitative measures for determining and analysing learning effect in terms of an increase in knowledge on the part of the learner can be implemented.. In theory, therefore, it should be possible to perform an evaluation which only focuses on the learning outcomes (frame 4), gaining evidence from quantitative changes in knowledge (frame 5) and using as the source of data standard tests and quizzes delivered prior to and after the delivery of teaching using the courseware or comparing the intervention with the 'traditional' form of delivery (frame 6). However, the tools which are used to measure the learning effect must be applied very carefully in order to ensure that the learning effect which has been measured is in fact directly attributable to the courseware itself and not to other contextual factors. The role of formative evaluation assumes a greater importance which is inversely proportional to the reliability of the instruments used to measure learning effect (subject to the provisos discussed in Chapter Six concerning the application of pre and post testing and ensuring that changes in knowledge can be attributed to the courseware itself). Thus changes in knowledge can be accurately determined using assessment instruments such as short quizzes or multiple choice type tests. However when we try to measure changes in cognitive skills or examine changes in higher order thinking skills the tests themselves are more difficult to apply and give less reliable results.

Bloom's taxonomy of learning outcomes is well established in higher education and is often used to inform course designers of the important levels at which teaching and learning must be delivered and assessed (Bloom, 1956). Similarly the use of level descriptors such as Bigg's SOLO (Structure of Observed Learning Outcomes) taxonomy provides an indication of the types of learning outcomes which should be apparent in any educational intervention.(Biggs and Collis, 1992). SOLO, however, describes five levels of sophistication which can be found in learners' responses to academic tasks (Biggs, 1996). Biggs describes these on the basis of the level of structure which is apparent in student response to a task, these being prestrucural, unistructural, multistructural, relational and extended abstract.. In many evaluations of courseware, unfortunately only the lower levels of such taxonomies are tested in outcomes measures. Whilst this may be adequate in a behaviourist environment it is not sufficient when evaluating cognitivist and constructivist environments.

Very few educational interventions would see their objectives as being purely behaviourist and would point to some feature of the courseware that claimed to develop higher cognitive skills. In such cases it is important to stress that outcome measures based purely on quantitative tests need to demonstrate a change in the level of cognitive skills of the learner. Jackson reports that:

> *the most fruitful route to gathering this data is by analysis of students' written work using a protocol based on the SOLO taxonomy (Jackson, 1999).*

He also notes that alternatively analysis can be made of students reflective written or verbal reports and quotes studies by Gibbs as good examples of this reports. (Gibbs, 1993). Such studies are closely related in approach to discourse analysis and are based on the premise that when a learner has understood a concept this will have an impact on subsequent actions outwith the context in which the understanding was gained. Thus Biggs proposes a list of 'performances of understanding' which are designed to match different levels identified in the SOLO taxonomy (Biggs, 1996).

Such tools can be used to gain a measure of cognitive abilities. However, in practice, it is more common for evaluation studies to use affective measures to examine user interaction with learning material and detect the development of cognitive skills when formatively evaluating courseware (frames 2 and 3) rather than attempting to provide an outcome measure associated with testing the development of such skills as part of summative evaluation.

Thus when evaluating courseware which claims to be wholly cognitivist in its pedagogic approach or which claims to develop cognitivist skills through particular features of the courseware (commonly simulations or interactive tasks) it is necessary to elicit detailed feedback and to examine affective outcomes in summative evaluation (frame 4). The purpose of the tools used to measure outcomes must not be restricted to examining changes in knowledge but need to provide evidence of changes in attitude or abilities which reflect a change in the manner in which the user can manipulate and process information.

If the objective of the courseware is to explicitly develop a constructivist design to promote the learner's own construction of knowledge then the evaluation becomes extremely complex and the mechanism for establishing measurable outcomes has not been clearly defined in the literature. Some commentators have argued that by definition it is not possible to measure changes in knowledge and understanding as outcomes of a constructivist intervention in education because by definition these changes are particular to the learner's own knowledge construction. (Bostock, 1998). Jackson notes that a constructivist view of learning recognizes the central importance of the learner and the significance of context on learning. (Jackson, 1999). Thus outcome measures are so bound up in the learning situation and peculiar to the particular learner that any evaluation could not be transferred out of the context in which the learning took place. Complex attitudinal measures which are directly related to the user's perception of how to perform a task and relate conceptual learning to real world applications of knowledge and understanding are possible solutions to the dilemma of having to provide some form of measure of 'success' in using constructivist scenarios; however, there is no evidence of any such studies in the literature concerning CAL evaluation.

Such evaluations as have been conducted on constructivist environments (see for example Stoney, 1999) rely very heavily on detailed observation of students and avoid any attempt to quantify learning outcomes. Use of think aloud protocols, automatic tracking of learner actions and other observational studies can give an indication of the cognitive process involved but ultimately these can only provide an incomplete picture.

Cognitivist and constructivist approaches by definition imply the development of 'deep learning' and this opens the potential for evaluation based on long term impact of use of such courseware by students. Again, however, this is plagued by the problem already noted in this chapter in the context of delayed pre and post testing - i.e. the problem of being sure that the impact being measured is attributable to the courseware itself and not to other factors which may have subsequently influenced the learner.

8.7.2.4 Learner Differences

Obviously there is a need to be clear about subject content, delivery level and the intended audience for the courseware being developed and thus in any evaluation all of this should be described in detail. More importantly the critical issue is to state clearly whether the courseware is designed:

1. to serve all users equally

or

2. to be used to benefit a particular type of learner.

If it is the intention that the courseware is to be a resource which serves all learners equally then the issue of assessing individual differences and accounting for them in the evaluation results is very important. Thus it is necessary to develop and use detailed learner profiles (frame 2) and to correlate any evidence of quantitative or qualitative changes reported at the summative evaluation stage (frame 4) with key learner differences as evident in the profiles. Indeed if in addition the context in which the courseware is delivered is one in which it is intended to replace existing teaching methods then this becomes an imperative. Key learner variables which have been identified in Chapter Six are prior domain knowledge, motivation, age and gender of learners, learning style and attitude towards use of technology.

8.8 Conclusion

This chapter has provided the background and rationale for different approaches to evaluation and some of the most important problems associated with practical evaluation. Using the discussion provided in previous chapters gives the basis for presenting a framework which covers a wide variety of situations in which CAL courseware can be assessed. The framework is necessarily complex but this is an accurate reflection of the complexity of the evaluation process itself.

The next part of the thesis will examine the application of *this fram*ework to developing and delivering a CAL courseware resource.

It would be impossible to test the full framework within the context of the research conducted here. However, the researcher has taken the most common type of approach to courseware development in order to create some teaching materials which can be used as the basis of testing the accuracy of parts of the framework as a guide to conducting a practical evaluation and to illuminate the manner in which contextual issues impact on the evaluation.

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Evaluation of the development and application of multimedia computer assisted learning in Higher Education

Volume II

A thesis submitted to the Robert Gordon University in partial fulfilment of the requirements for the degree of Ph.D.

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Chapter Nine

Development of Prototype CAL package

Multimedia is a jungle: full of life, dazzlingly diverse, yet an easy place in which to get lost. However far you travel, you can never see very far ahead, and the place is full of predators, swamps and pitfalls lying in wait for the unwary. What we all need is a map, something that suggests pathways and communicates experience without being prescriptive - something above all else perhaps that identifies the swamps and predators without deterring exploration. Sadly, no such map exists, but in principle at least, that is what these guidelines are seeking to become.

(Davies, P. and Brailsford, T. New Frontiers of Learning: Guidelines for Multimedia Courseware developers in Higher Education. Vol. 1 Delivery Production and Provision, 1994)

9.0 Objectives

The objectives of this chapter are to describe the methodology used and the process involved in developing a demonstrator CAL package to support empirical studies on evaluation which were conducted as part of the research. Specifically the chapter will:

- Outline the rationale for developing a demonstrator CAL package
- Describe the methodology used in development and testing of a demonstrator CAL package
- Discuss the outcomes of the process of development in relation to the framework for evaluation defined in the first part of the thesis

9.1 Introduction

The first part of the thesis was concerned with developing a framework for the evaluation of CAL systems. Thus the thrust of the investigation described in the first part of the research has been largely geared towards examining the manner in which multimedia CAL systems support the delivery of teaching. A much more complex issue, however, is the evaluation of CAL materials in relation to their effectiveness in supporting student learning. This theme is developed in the second part of the thesis which is concerned with achieving the second and third aims of the research (Chapter Two) which were:

- to develop multimedia CAL courseware as a tool which could be used to test the validity of claims made in the literature relating to the benefits of multimedia CAL and to examine in detail (and from the learner's perspective) the mechanisms by which this package supports student learning
- to test the framework for evaluation by using it to evaluate the courseware package developed as part of the research programme and, as a consequence of following that framework, to investigate the extent to which the multimedia CAL system supports all learners equally by examining the influence of individual differences between learners on their perception of the CAL system and their performance in using it in an authentic learning environment

In order to achieve the aims given above the research pursued the following objectives:

- to develop and formatively and summatively evaluate a CAL package designed to support the teaching of parts of a module in bibliographic classification;
- to use the CAL package to investigate claims made in the literature about inherent benefits of CAL courseware;
- to use the CAL package to investigate the influence of key issues which relate to individual student perceptions and background attitudes to using CAL materials;
- to investigate the manner in which a multimedia CAL package is used by students with particular reference to exploring individual learner differences;

The rationale for developing the CAL package was thus to provide a better understanding of the problems of formative and summative evaluation of multimedia CAL than could be gained purely by a study of the literature. The process of developing the CAL materials itself was an important activity that permitted monitoring and critical evaluation of the practical issues which influence and constrain the production of CAL courseware thus leading to a deeper understanding of some of the issues concerning evaluation of CAL as discussed in the literature. In addition it provided a tool with which to examine specific research questions that arose out of the literature and to corroborate or refute certain assumptions or claims which the current literature makes concerning the use of multimedia CAL. Finally it provided a tool which could be used to test the framework for evaluation of CAL packages in higher education, in particular to test the robustness of the framework's application to evaluating aspects which concern learners' attitudes and performance when using CAL

Following the framework for evaluation the development and evaluation of the courseware package can be described in three phases. Some of this work was conducted in parallel with work that has previously been described in Part One of the thesis. The three phases are:

1. Initial design and rapid prototyping of the demonstrator courseware
2. Formative evaluation of the interface in order to accommodate user feedback and test assumptions made in the literature concerning the manner in which multimedia CAL facilitates learning. This was accomplished by iterative prototyping to ensure that issues relating to design of the courseware were addressed followed by a phenomenographic study of use and user attitudes to the courseware.
3. Summative evaluation to establish whether, in an authentic context, the courseware had achieved its objectives. This contrasts with formative evaluation where the emphasis had been on establishing that the system was perceived to be useful and functioned effectively. In addition the data provided in the summative evaluation were tested with respect to a variety of factors related to individual differences of learners in order better to explain and interpret the results.

This chapter will deal specifically with the development of the prototype CAL package and will discuss both the methods used to do this and the resultant courseware package produced. Phases two and three dealing with formative and summative evaluation are dealt with in Chapter Ten and Chapter Eleven respectively.

9.2 Development of the prototype CAL package

This first phase of the research involved the selection of a topic for delivery using CAL, defining clearly the aims and objectives of the CAL materials (using the evaluation framework developed in Chapter Eight to inform this process and selecting a suitable authoring package to create prototype CAL courseware for delivering the topic. These activities are summed up in Table 9.1.

Table 9.1 Summary of development of prototype CLASSICAL package

Date	Activity	Outcome
January-May 1994	1. Development of CAL objectives and context in which courseware would be implemented 2. Develop proficiency in use of authoring system 3. Design the user interface	Initial design of CAL systems including a definitive assessment of objectives, content, and environment for implementation
June – August 1994	1. Rapid development of prototype package	Prototype of 'CLASSICAL' a multimedia CAL system for teaching bibliographic classification

9.2.1 Choice of topic for delivering using CAL

The subject chosen for the CAL package was bibliographic classification. The benefit of using this subject is that it is a core element of both undergraduate and postgraduate courses in Information and Library Studies offered by the School of Information and Media at the Robert Gordon University. The subject is taught in 'traditional mode' as a series of 10 lectures and seminars and 8 practical sessions. The aim of the lectures and seminars is to provide a framework of knowledge and understanding of the importance of bibliographic classification and the principles upon which bibliographic classification schemes are constructed and used. The aim of the practical sessions is to introduce students to two of the major bibliographic classification schemes that they will use in practice - the Dewey Decimal Classification Scheme and the Universal Decimal Classification Scheme. At the outset of the research programme there was no existing CAL courseware available to support teaching in this area (nor indeed in any core area in Information and Library Studies). Collectively the CAL package incorporating both lecture based and practical sessions was named 'CLASSICAL' (**CLASSI**fication using **CAL**)

As noted in Chapter 5 prior domain knowledge is a complex learner variable and it is very difficult to interpret findings of an evaluation if this variable is not carefully accounted for – not least because it is not known what differential in learning gains can be expected because of the degree of prior knowledge. An additional benefit of choosing bibliographic classification as a subject was that the topic is one which neither postgraduate nor undergraduate students had been taught prior to undertaking the course within the School of Information and Media. The subject is not taught as part of the curriculum in secondary education. Whilst students may have varied backgrounds in terms of acquisition of generic or transferable skills which could be applied to studying the module there was no difference in prior knowledge and understanding of the key facts and principles which were being expounded in the lecture materials and in the practical sessions.

Specific aims and objectives of individual lectures and practical sessions had already been set out in the 'traditional' teaching programme and did not require change. Thus the perceptions of students regarding the value of the courseware as an alternative to the 'traditional' method of delivering parts of the course were not compromised by the problem of attempting to assess courseware on the basis of aims and objectives which had been specifically tailored to the medium being used. This therefore addressed the concerns of critics such as Clark who note that in meta-analytic studies which measured learning effect no account was taken of the fact that in part this could be attributable to the different and specific learning outcomes which were designed for the courseware itself.

Finally it should be noted that in part the choice was also pragmatic and practical in that it was a subject area in which the researcher has over ten years experience of teaching and researching and thus the material to be used in developing the courseware was readily available.

9.3 Establishing objectives for courseware use and implementation

The framework for evaluation described in Chapter 8 emphasises the importance of stating clearly the objectives for a particular implementation of CAL (or, for an existing CAL package, of establishing these objectives) and that these should be framed in terms of the intended audience, the pedagogic approach and the context in which courseware is to be used. This forms the basis for formulating the objectives or research questions that the evaluation itself will seek to address. This also constrains the type of hypotheses or research questions that can be addressed. It was further noted that this process could be facilitated by the use of checklists to prompt the developer to consider critically these issues. Brown's checklist 'The CAL component of a course: points for consideration' (Appendix 4) which is provided as an appendix to the TILT group's position paper on Observing and Measuring the Performance of Educational Technology (Draper et al., 1994) was used at the outset of the research as a useful checklist to clarify the issues which have to be addressed before beginning any development of educational courseware. The publication of this report just prior to the outset of the research presented here was timely and use of the checklist was instrumental in crystallising issues which were important in assisting the formulation of a clear plan of action for developing the material. Brown's checklist was used to plan and record the issues considered at the development phase of the courseware. The decisions are summarised in Table 9.2 and structured according to Brown's checklist prompts.

This exercise revealed some interesting points both about the important features to be considered when developing and evaluating CAL and about the specific approach being taken by the researcher to developing a CAL package.

Table 9.2 CAL component of a course : Points for consideration (derived from Brown's checklist - See Appendix 4)

Checklist prompts	*In relation to the proposed development these were:*
1.Reason for use	to supplement and in part to replace present teaching methods to allow existing coursework to take place effectively independently of direct staff contact (e.g. drill-based activities usually taught in small groups or even one-to-one) to improve the quality of teaching
2. Production of Package	1 staff (the researcher) required to author programme IBM-PCs (386DX specification) to be used Multimedia authoring software to be used 10 teaching units to replace lecture delivery 8 teaching units to supplement practical activities Completion of each unit to be possible within the 1 hour slot normally reserved for the activity in 'traditional' teaching
3. Type/style of software	Multimedia User control paths with tracking to record student's path through package
4. Availability of CAL to students	12 IBM PCs (based on limitations of laboratory space) Compatibility with other machines not required 1 hour time slots scheduled and time to be allowed for independent use single and repeated use of package individual use of CAL (as opposed to group working)
5. Additional resources	None
6. CAL approach/design	Assessment: formative evaluation should be incorporated The general approach should be 'computer as instructor' and thus clear exposition of the subject and (drill and) practice and problem solving should be incorporated
7. Assessment	Formative assessment should be build into the package and the material should support summative assessment as part of the course module
8. Lecturer/Tutor	Under this heading Brown notes considerations relating to tutor motivation and support/training. These are obviously important factors to be considered particularly with respect to third party evaluation of CAL. More significantly the issues of style of introduction of CAL to the students and the interaction of the tutor with the students needs to be stated clearly. In this case it was determined that the material as far as possible could be used independently and the tutor should not be directly involved in sessions in which the students used the courseware.
9. Student	Under this heading Brown supplies a number of characteristics of the learner e.g. prior knowledge of subject, motivation, attitude, age, gender, learning strategy. All of these are important in the evaluation stage but in terms of development the only consideration which was made was that the practical based elements should be designed for open access and individual use by undergraduate students and that 'lecture based materials' should be used by postgraduate students
10. Evaluation and update	The system was being developed specifically to support research into the evaluation of CAL packages. Considerations for maintaining and updating the package were not considered important.

With respect to the development of the courseware being produced as part of the research the responses to the questionnaire clearly indicated that there was a dichotomy in purpose which became apparent when considering the manner in which it was envisaged by the researcher that the courseware would be used. In particular the conditions of use which were originally envisaged for the lecture based materials (which were very much didactic in purpose and intended to be used in place of 'corresponding lectures on particular topics) were quite different from those envisaged for the practical based materials (where it was planned that there would be scope to provide more support and guidance by allowing students the opportunity for more practice than could be accommodated in a traditionally delivered practical class). This would have important consequences for how these different types of courseware should be evaluated particularly at the summative evaluation stage. In order to maintain a clear separation of these objectives it was decided that, although the subject material was equally useful for both groups of students, evaluation of use of the practical based materials would be conducted using the undergraduate cohort and evaluation of use of the lecture based material would be confined to the postgraduate cohorts.

With respect to evaluation of CAL, Brown's questionnaire, which is designed to inform the development process, clearly reveals the complexity of the undertaking and the many different facets which must be considered. It provides an important starting point for considering the overall aim of the courseware (1); the context for development in terms of resources used (2-5); pedagogical and design approaches (6 and 7); context of delivery (8); individual differences (9) and issues for evaluation (10). This provides support for the application of the framework for evaluation developed in the first part of the thesis. Each of these themes can be seen to contribute to the formulation of clear objectives based on understanding institutional/delivery context, pedagogical aims and learner differences. Application of the checklist thus results in a more precise statement of aims and objectives which will be of key importance in designing an evaluation strategy clearly framed in the context of what the CAL was intended to achieve.

The objectives which were framed for the CAL package were as shown in Tables 9.3 - 9.5.

Table 9.3 Objectives framed in terms of Institutional/Delivery Objectives
• ***To replace parts of the programme of lectures for postgraduate students using multimedia CAL courseware whilst maintaining the same quality of learning*** • ***To supplement practical sessions delivered as part of taught modules in bibliographic classification for undergraduate students by using multimedia CAL courseware and thus improve the quality of learning***
The courseware was designed to be used by students as an aid to independent study. It was not designed for use by groups. The courseware was initially designed to operate on networked IBM PCs situated and prior to summative assessments it was converted to allow it to run on a local area network. The courseware was available in one laboratory within the Faculty of Management building of the Robert Gordon University. Due to problems with the network the software was loaded onto individual machines for the purpose of summative evaluation tests. From the perspective of the students this had no impact on the conduct of the tests as any data which they themselves created (in the form of notes taken when using the courseware) were written to floppy disk. It made collection of on-line comments from students slightly more problematic for the researcher as each stand-alone PC had to be checked and any relevant files copied from there to floppy disk for subsequent examination or (in the case of log files for tracking use) analysis. Given the discussion of the complexities involved, within the remit of this work A detailed consideration of costing of resources was not deemed to be feasible though it can be noted that the resource was created using no additional hardware or software. Thus, significantly, **establishing cost effectiveness was not part of the objective of the evaluation**. All resources were either already available within the School of Information and Media or were purchased in order to support teaching development in a variety of subject areas taught across the School. No additional staffing resources were used to develop or to test the courseware which was developed.

Table 9.4 Objectives framed in terms of Pedagogic Context
• ***To create courseware to transmit the content of parts of a course in bibliographic classification providing comprehensive coverage of all material that is delivered in a face to face lecture*** • ***To create courseware to support additional practice in use of a standard for bibliographic classification and thus to enhance students practical skills.***
The CAL courseware was to be used to deliver material that had traditionally been delivered using lectures or practical seminars. The objective of the courseware was to provide a didactic model which would allow the researcher to transmit lecture content and practical tutorial materials to the students using the courseware. In both cases the basic approach adopted was essentially behaviouristic and transmissionist. Cognitivist tools such as concept maps and provision of hypertextual links were adopted in designing the courseware but the role of these tools was seen as enhancing the ability of students to interact with the material presented and to assist them to use the online material effectively. There were no unique features (e.g. simulations, video case studies or problem based scenarios) which were designed as part of the courseware which made the courseware itself distinctive from the material provided in traditional face to face teaching.

Table 9.5 Objectives framed in terms of Learner Context
• **To provide courseware which would benefit all students equally as an alternative to traditional lecture based delivery** • **To provide courseware which would allow students who required additional support to consolidate and develop their practical skills independently**
The courseware was designed for use by postgraduate and undergraduate students registered on the course modules 'Concept Retrieval' (postgraduate) and 'Bibliographic Standards' (undergraduate) in the School of Information and Media. Students are full time campus based learners and the module contributes towards their Postgraduate Diploma in Information and Library Studies or BA degree in Information and Library Studies. The subject matter of the course was appropriate for both undergraduate and postgraduate cohorts. In particular the practical classification tutorials were equally appropriate for use with both undergraduate and postgraduate classes. Thus to provide a broad base of comment for the initial prototype and in more detailed assessments made in the formative evaluation of the system both undergraduate and postgraduate students were involved in testing and commenting upon the system design and usability. However, for the practical reason of reducing potentially conflicting variables summative evaluation of the courseware it was appropriate to use the lecture based materials with the postgraduate students and to use the CAL materials for teaching practical skills with the undergraduate cohorts. Postgraduate studies are very intensive and experience of providing them with additional materials to supplement lectures has shown that this is often not used because of the limited time they have to devote to study. With less pressure in terms of time allocated to study for the module undergraduate students could be more easily directed to use material which provided additional information and practice than was possible in timetabled practical laboratories. As noted in the evaluation framework an important consequence for the evaluation strategy for the coursework replacing current teaching methods was to demonstrate that all learners were served equally by the material. Thus individual student profiling was an essential part of the evaluation. For the practical based material it was necessary to show that the additional resource was perceived as useful and to examine any overall change in learning which resulted.

9.4 Choice of authoring program

In determining the software to be used for authoring, although it was envisaged that the content of the packages would be predominantly text, the ability to easily incorporate multimedia elements was obviously important. The criteria for selection were that the system chosen had to:

- run on an IBM PC platform (the standard laboratory specification was 386 DX microcomputers - HyperCard and Supercard which were designed for Macintosh PCs were therefore not considered)
- provide an authoring environment in which most standard tasks could be completed without recourse to use of complex programming languages
- allow the integration of different digital media formats
- provide a run time version in order to allow easy dissemination of courseware
- have an established user base to provide opportunity to gain advice and support on development (The experiences of the TILT group in Glasgow in converting CAL materials from Guide was another important consideration which influenced the decision to develop the CAL material on a platform which was in mainstream use in Higher Education.[1])

In the first instance a range of publications, mainly arising from the ITTI programme, were instrumental in providing guidelines on selection of authoring systems. (Davies and Brailsford, 1994; Edwards, 1993; Edwards et al, 1994; McAteer and Shaw, 1995; Riley, 1994; Vaughan, 1994). Moreover, a number of authoring packages were becoming established as 'standards' within the higher education community in the mid-1990s (notably Macromedia Director, Asymetrix Toolbook and Authorware). These were evaluated for fitness for purpose. Ultimately the choice made between these systems was based on preference for a particular approach to design and ease of use. Authorware Professional is an icon based tool and the overall structure of an application is specified through a series of icons which supports a 'visual programming' approach. The structuring of applications, however, tends to favour a linear, progressive approach where the user works through the application in a 'forward' direction. As Boyle notes:

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[1] *Creanor, L. et al. (1995) A hypertext approach to information skills. Development and Evaluation. University of Glasgow: TILT*

> *Authorware was not constructed as a hypermedia or hypertext authoring tools (sic). If you want a highly flexible movement between nodes of information you may find a 'data' based approach such as that used in Toolbook to be more suitable.(Boyle, 1997 p.144)*

Macromedia Director follows a time based approach, using the analogy of a stage production, and again follows a fairly linear time based approach which is particularly effective for creating presentations. Asymetrix Toolbook provides a more structured environment based upon using a page and object based approach and supports easy construction of very flexible architectures. The approach is based on a familiar 'book' metaphor and as a consequence the system is very easy to conceptualise. It allows easy handling of a range of multimedia data types and the system includes a good range of tutorials and libraries of page templates. It also incorporates a powerful programming language – Openscript - and the package includes range of useful widgets (pre-scripted objects). In addition it was noted that there were a number of existing applications which had been developed specifically for use in higher education based on Toolbook. Thus Assymetrix Toolbook was selected as the authoring package.

9.5 Familiarisation with Authoring System and Interface Design

Initial exploration of Asymetrix Toolbook showed it to be possible to approach the design of the courseware packages by using a standard 'template' for creating a courseware package into which a number of additional features and functions could be integrated.

At the same time as developing skills in Asymetrix Toolbook literature based research was undertaken on the design of CAL software. In particular the question of navigational interface design, screen design and layout, granularity of chunks of information presented and methods for incorporating formative assessment and feedback. It was deemed inappropriate to provide sophisticated cognitive tools that are essentially instruments for supporting constructivist learning environments (See Chapter 4). In relation to the pedagogic objectives of this package See Table 9.4) they were not essential. As far as was practical, however, features were included in the courseware which were based on sound theoretical design principles as advocated in the literature.

9.6 Rapid prototyping of CAL package

Rapid prototyping is part of Rapid Applications Development (RAD), a methodology for systems development which has gained considerable currency in information technology departments both in commercial and academic sectors. A formal non-proprietary RAD method called the Dynamic Systems Development Method was introduced in 1995 (DSDM, 1995) and is advocated by several experts on courseware design and development, notably by Boyle. (Boyle, 1997). In contrast to traditional approaches, typified by the SDLC (Systems Development Life Cycle), which advocate a linear approach to project development, rapid prototyping involves the developer in creating a working model of the application at a very early stage in product development. This protototype can support the communication process between developer and potential users as it allows the users to visualise the potential of the courseware and forms a basis for informed feedback on content and design. This methodology was deemed to be particularly appropriate for the development of the CAL courseware in the context of this research because it encourages a user-driven approach to evaluation.

The courseware was to be designed to incorporate teaching delivered in a series of 10 lectures and seminars and 8 practical sessions. A prototype system was developed which contained the teaching materials for 3 of the lecture sessions and one of the practical sessions. The delivery of these modules formed the basis for most of the tests that were conducted during the formative stage of the evaluation.

The assumptions on which the design of the prototype were based were derived from the literature concerning hypertext/hypermedia and general works on design principles. These were obviously constrained by practical limitations because some of the very sophisticated features which are advocated in the design of interfaces could not be easily achieved without devoting an inordinate amount of time to development work. Hence, compromises had to be made based on the perceived value of design elements to the overall objective of providing a simple to use interface which allowed learners to have access to all of the relevant material and to sufficient flexibility in the manner in which they processed the information presented. At the stage of developing the prototype the method adopted was to quickly implement a number of features which would provide users with a basis for comment and criticism. It was then possible to be flexible in responding to comments from users about how to refine the interface based on explicit feedback which suggested modifications to the interface and on observation of the manner in which design features or tools were being used.

9.6.1 Prototype for lecture based material

In order to accommodate delivery of lectures the approach taken was to develop a suitable interface to present 10 CAL units each based on a lecture and containing all of the information provided in the equivalent traditionally delivered lecture. This included all factual information, overheads which provided a structure for the content, references to additional reading, and examples to illustrate key points. Figure 9.1 shows a 'lecture page' from the prototype CAL package. These lecture based chunks were contained within a single window and the user could scroll through the contents of the lecture. The 'overhead' provides a map of the contents for a particular lecture. This was permanently displayed on the left hand side of the screen. This allowed the user to navigate quickly to a particular part of the lecture.

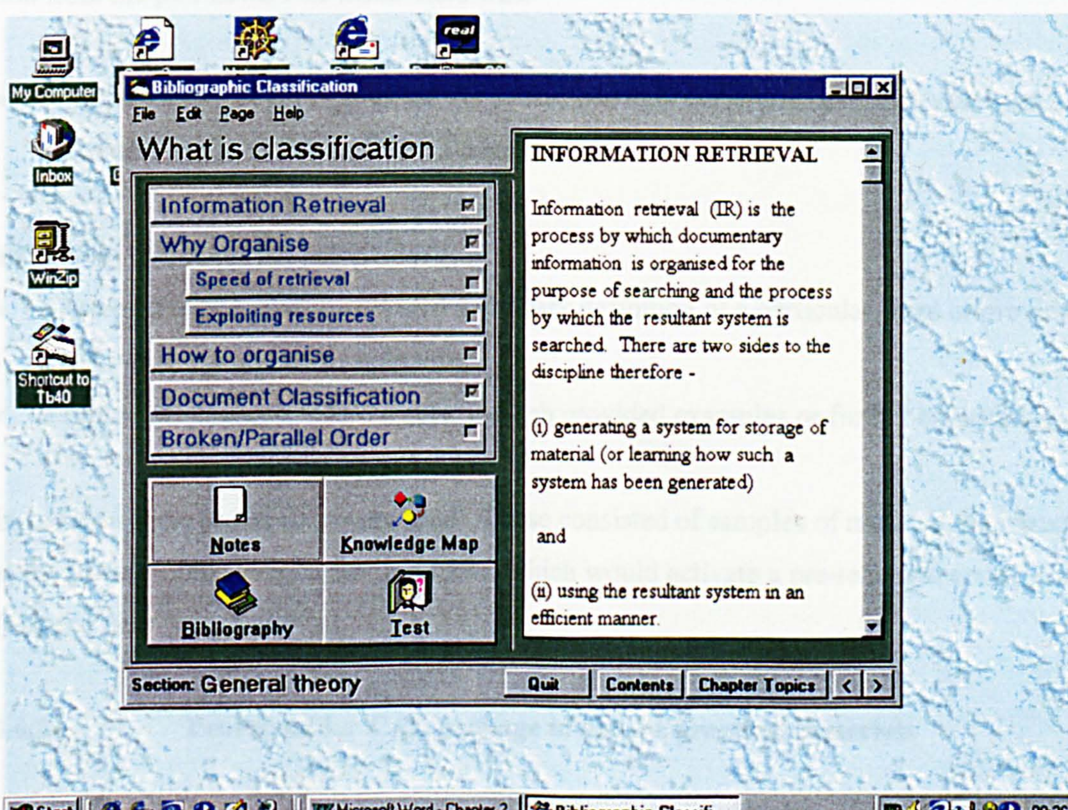

Figure 9.1 Sample page from prototype CAL application for lectures

In addition a set of tools were provided which could be activated by using the appropriate button. These were situated below the 'overhead'. The following tools were provided:

- bibliography of sources used to compile the material and recommended further reading
- an overview concept map (knowledge map) of all lectures and topics demonstrating the connections between topics
- a facility to take notes - notes could be stored on the floppy disk drive at the end of the CAL session and during the formative evaluation were used to feedback to the course tutor (to do this notes were stored on the hard disk drive of the computer being used and accessed later by the course tutor).
- A facility to allow the learner to take a short test based on the material contained within the lecture

and from the pull down File menu there was:

- a search facility to quickly locate the occurrence or occurrences of a particular work (activated from the File pull down menu)

and within the text of the lecture itself:

- a hotword feature which provided a glossary definition of a particular word or provided the citation for a quotation or reference
- a further information icon (an 'eye') which provided examples or further explanations

In addition some sound files were used. These consisted of samples of music at the introduction to the package and some sound 'hot spots' which would activate a pre-recorded verbal comment from the tutor.

9.6.2 Prototype for CAL package to deliver practical materials

For delivering the practical instruction involved in training students in the use of bibliographic classification schemes a different approach to design was required than that used for presenting didactic 'lecture based' material. The practical tutorials were designed to make use of a much wider range of graphic material and allowed students a great deal of control over the order in which they viewed information and the extent to which they took the opportunity to practice using examples provided or engage in self-assessment. After an initial introduction to the basic layout and content of the bibliographic classification scheme being used, students were allowed to select topics for further study based on a variety of practical techniques which they were required to master. The subject for the prototype was based around practical classes in using the Dewey Decimal Classification Scheme. The classification scheme is published in four volumes and the first task generally tackled in teaching students use of the scheme is to provide some form of overview of the four volumes in order to ensure that students are familiar with the overall structure of the scheme. This was, therefore, used as the basis for the opening part of the CAL package. (See Figure 9.2 below). In this case the graphics of each volume of the classification scheme functioned in the same way as the 'overhead' screen in the lectured based CAL prototype i.e. allowing the student to quickly access one particular topic.

This was followed by a number of practical 'lessons' which defined different steps dealing with practical techniques. These started from fairly simple techniques and became increasingly more complex and for each technique some details of principles and an example of how the scheme should be used was provided. The student was also given the opportunity to review the principles which were important in each technique, to examine some worked examples or to practise the technique independently by working through a series of similar examples (See Figure 9.3 below).

9.6.3 Structure and Navigation

During the design of the prototype considerable attention was given to the manner in which the teaching material was structured as one of the most significant issues which was evident in the literature was the importance of navigation aids for learners. (Conklin, 1987; Shubin and Meehan, 1997; Dix et al., 1998). Generally this is associated with the extra pressure or cognitive overhead placed on users when navigating an information space in which there is a dearth of the usual visual cues associated with print based materials. The approach taken in development of the CAL package prototypes (typical of many other CAL applications) was to use the metaphor of an electronic book. An explicit navigational tool needs to be provided in order that the teaching material is separate from the means for accessing it (Evans and Edwards, 1999). However, it also has to be noted that in an educational context the structure of the material lends itself to either a linear, hierarchical or directed network approach into which the course components should

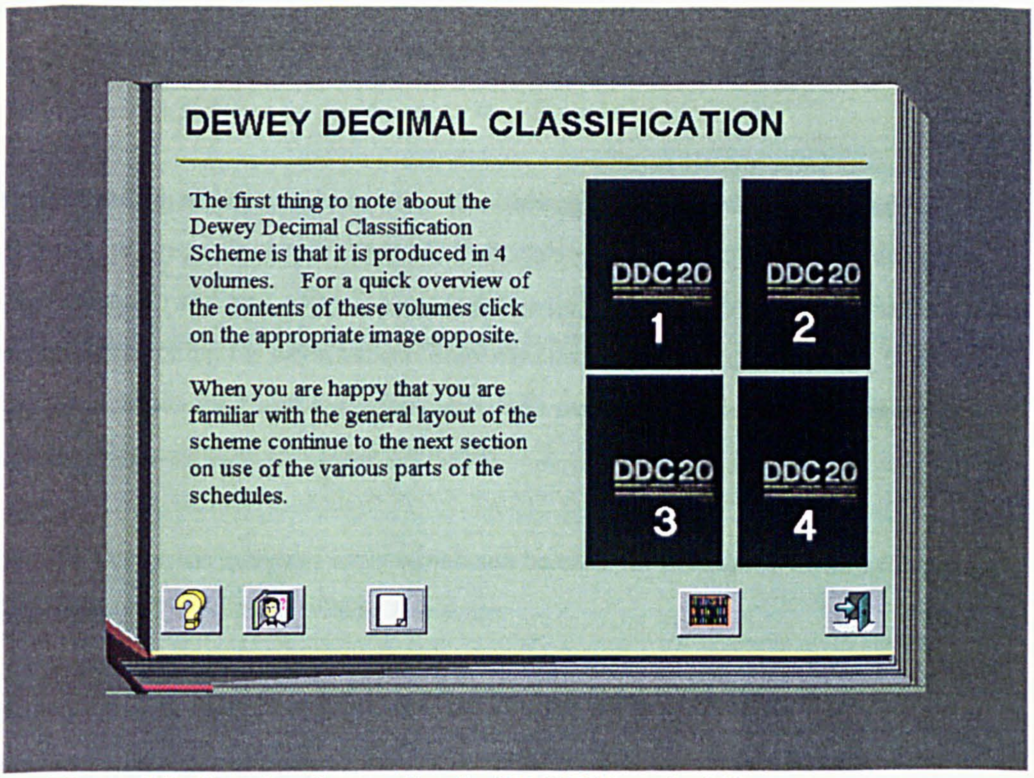

Figure 9.2 Opening Screen for the DDC20 Practical Courseware

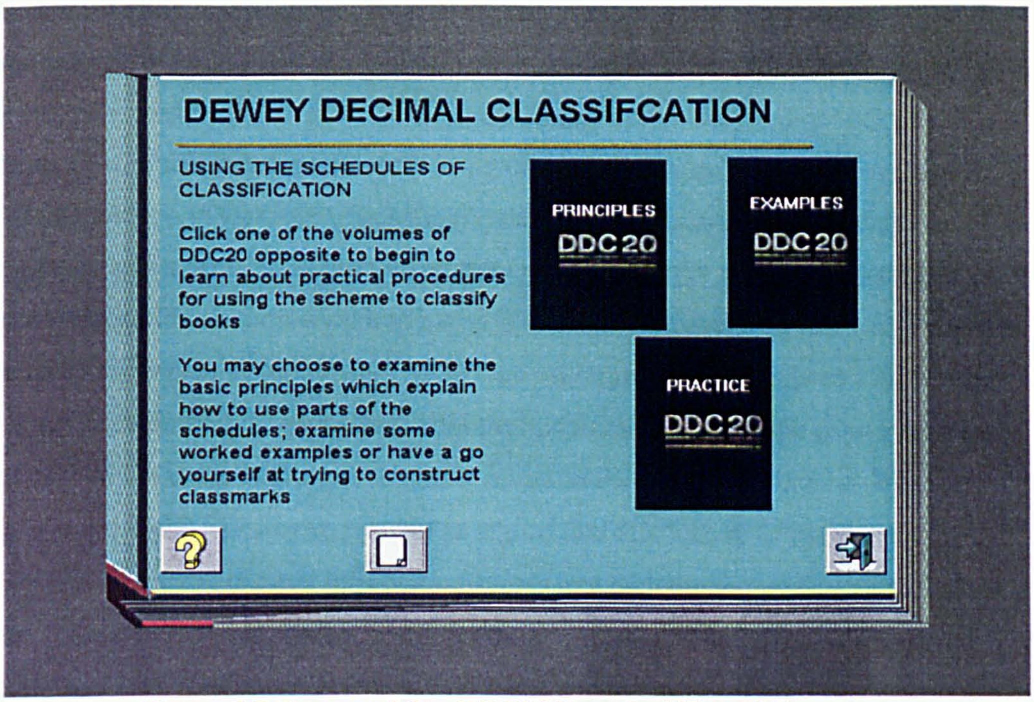

Figure 9.3 Screen of the DDC20 Practical Tutorial

logically be placed. These three basic structures are determined by the teaching material itself and reflect the manner in which it has to be conceptually associated in order to direct students to a successful understanding of key concepts. It is often wrongly assumed that books and instructional manuals have a linear structure. In fact textbooks often display a high degree of hierarchical organisation and also provide tools (such as the table of contents or the index) which support associative searching for information. They also use specific design features (such as typographical conventions for chunking information into paragraphs and clearly delineating section headings) which support purposive browsing.

Goldberg identifies three navigational tools which can be used for traversing information in a CAL teaching package. (Goldberg, 1996). These are:

- Sequential (unidirectional)
- Menu (hierarchically directional)
- Map (omnidirectional)

A combination of all of these navigational approaches may be presented in the interface and they present increasing degrees of complexity both in terms of designing the interface and for using the resultant structure. Sequential organisation (which simply allows forward or backward navigation from a particular node) is obviously of particular importance when considering the sequencing of information in topics in which the physical limits of page size on a computer screen have necessitated a decision to use two or more pages to convey a single logical unit of information on a topic. Physical division into pages in this case does not bear any relation to the logical structure of the course material itself. Map type structures have often been advocated as an aid to navigation particularly because they offer the opportunity to show the connections and 'associative links' which many authors see as being a central feature of multimedia design. (Beasley and Waugh, 1995). However, it could be argued that this feature of maps is more appropriate for the navigation of large information spaces in which the sequencing of the nodes is not significant. In addition, when applied to the design of educational software there does not appear to be any evidence that the map itself provides any support for learners' acquisition of knowledge about how the different parts of a complex topic are inter-related (Jonassen, 1993). Indeed a study which examined the use of hypermedia by students with and without a map tool actually found that there was a detrimental effect on navigational performance when the map tool was used (Stanton et al. 1992).

The prototype systems were therefore based around hierarchical organisation of information with sequential browsing through specific topics. For some of the content where a number of important points were subsumed under one heading, this involved the use of sibling menus to make the structure of the material more evident to the learner.

Given the prominence of navigational strategies in the literature and the fact that recording this appeared to provide a good indication of usability of courseware, it was decided that an investigation of use of the navigational aids provided in the working CAL system should be undertaken and thus a tracking system was implemented. The anlalysis of the data derived from use of the tracking system is described in Chapter 10..

9.7 Commentary on Development Stage

The literature which deals with the development of CAL systems generally focuses primarily on the development techniques and design methodologies. However, the approach taken to development outlined in this chapter has been to focus much more specifically on the objectives of the courseware (which will determine that what is being evaluated) as the most important activity. This is in keeping with the observation which is often made in the literature that evaluation must not be an activity which is added or 'tagged on' to the end of the design process. As Laurillard notes:

> *[evaluation] is an iterative process and should take place at every stage of design, production and implementation of courseware.(Laurillard, 1993)*

This is consistent with the approach advocated in the evaluation framework developed in Chapter Eight. Likewise the contextual influences on the use of the system can be more clearly delineated by ensuring that the context for use is fully considered at the development stage. This provides a useful check against the possibility of losing sight of the original manner in which it was envisaged the courseware would operate and influence learning when subsequently evaluating the system.

Of course robust development methodologies are important particularly in cases where the time frame for completion of the work and financial constraints are significant. Whilst these were not of major significance to the research the approach advocated here using a rapid prototyping methodology was found to be very effective in permitting the speedy development of prototype courseware. Some of the problems surrounding development which are discussed in the literature (e.g. the tension between creativity and control (Boyle, 1997) and the complications associated with the need for copyright clearances (Ford and Graves, 1995)) were obviously not reflected in the development conducted as part of this research. These would be expected in the development of commercial products or development of large scale courseware packages involving a range of specialists which tend to throw up a range of issues related to project management and design.

In terms of the technical process it was found that the authoring tools available currently provide an environment for designing courseware which can be readily grasped by non computing specialists. Whether or not this resulted in courseware which was viable and useful for teaching, of course, could only be ascertained by testing the courseware and performing a formative evaluation of its functionality and its effectiveness in delivering the learning objectives for which it was designed. These issues are considered in the next chapter.

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Chapter Ten

Formative Evaluation

> *'I've got two pieces of bad news about that experimental English comp course where students used computer conferencing. First, over the course of the semester, the experimental group showed no progress in abilities to compose an essay. The second piece of bad news is that the control group taught by traditional methods showed no progress either'*

(quoted by (among others) Stephen C. Ehrmann from a talk by Roxanne Hiltz, 1995)

10.0 Objectives

The objectives of this chapter are:

- To discuss the methods and results of formative evaluation of the prototype CAL package

10.1 Methodology for Formative Evaluation

The second phase of the research focused on further development of the courseware through the formative evaluation of the CAL package. A variety of tests were undertaken in order to evaluate the manner in which students interacted with CAL materials. During the formative evaluation stage these tests were focused mainly:

- on confirming that the design and content of the system was perceived to be useful

and

- in investigating in detail the manner in which students interacted with the CAL courseware.

This approach reflects the importance (as shown in the for evaluation in Chapter Eight) of distinguishing clearly the use of formative evaluation as a tool which can be used to improve the functionality of the system which is being developed and the use of formative evaluation to gain more information on how the system actually operates.

In addition two tests were conducted to examine assumptions made in the literature which appeared not to have been adequately corroborated by empirical evidence or for which there appeared to be contradictory findings. These related to perceived and actual value of the use of a variety of media within CAL (discussed in Chapter 4) and the extent to which students made use of different strategies for navigation when using multimedia courseware (also discussed in Chapter 4). A summary of the tests which were undertaken during the formative evaluation phase is presented below in (Table 10.1).

The main methodological approaches taken to support the second phase of the research were iterative prototyping of the courseware and use of a phenomenographic approach to evaluate student use of, and perception of, the courseware. The first of these was prominent during the formative evaluation of the courseware itself and the second used during the evaluation of student use.

10.2 Formative Evaluation of the Courseware – Iterative Prototyping

Like rapid prototyping, iterative prototyping is a component of the Rapid Application Development methodology for developing systems. The initial demonstrator acts as the basis for gaining user feedback and comments and these are successively and incrementally used to improve the resource. Where a major system development is introduced as a result of this feedback it is necessary to re-test the acceptability of the system to users. The objective of the methodology is to ensure that user feedback is constantly being used to improve the resource prior to any formal procedures for summative evaluation of the completed courseware. The main way in which this methodology differs from conventional evaluation procedures involving planning, testing, then improving the resource (as advocated, for example, by Milne and Heath (Milne and Heath, 1997)) is that the objective of iterative prototyping tests at this stage is seen as been principally concerned with establishing problems or improvements which can be implemented *prior* to a subsequent evaluation stage which measures the effectiveness of the completed resource.

Table 10.1. Summary of formative evaluation tests

Date	*Student Group*	*Numbers*	*Activity*
FORMATIVE EVALUATION OF THE PROTOTYPE COURSEWARE			
September 1995 and February 1996	Postgraduate and 2nd Stage Undergraduate Students	62	1. Observations of use of CAL prototype 2. Questionnaires on CAL prototype 3. Structured feedback sessions
September 1995	Postgraduate Students and 1st stage undergraduate Students	54	4. Test on use of multiple media
Sep/Dec 1995	Undergraduate Students (Stage 3) Multimedia Technology Module	68	5. Assessment of the prototype CAL system design
February/March 1996	Postgraduate and 1st stage undergraduate students	54	1. Follow up test on use of multiple media
April –August 1996	No student involvement		1. Revision of prototype 2. Implementation of tracking facilities 3. Implementation of online user feedback facility
FORMATIVE EVALUATION OF STUDENT LEARNING USING COURSEWARE			
January-March 1997	Undergraduate Students	28	1. Questionnaire on CAL packages 2. Confidence logs issued and analysed 3. Structured feedback from groups 4. Analysis of tracking logs
April 1997 – August 1997	Revision of teaching material for lecture and practical programme		1. Additional lecture material added to courseware 2. Development of additional on-line tests for lecture material
September 1997	Postgraduate Students	29	1. Questionnaire on CAL packages 2. Confidence logs issued and analysed 3. Structured feedback from groups 4. Analysis of tracking logs

Obviously a potential problem with applying this procedure in an educational setting is that the composition of the body of users is changing on an annual basis. In practice, however, in terms of usability factors which are being described here, the needs of the users (i.e. the student cohorts for any particular year) are essentially stable.

The four instruments which were used to collect data on the prototype were:

1. Observation of use of the system
2. A questionnaire on CAL prototype
3. Structured Feedback Sessions
4. Assessment of the interface as part of a taught course on Multimedia Applications

This range of complementary methods was adopted to ensure that the data provided was not over-reliant on the defects of particular techniques and allowed triangulation results.

10.2.1 Observations of use

The most direct and easy of gathering information for an evaluation is through observation. In the third week of their study of bibliographic classification (i.e. after the delivery of two lectures and two practical sessions on the topic) students were introduced to the use of the multimedia CAL lectures and practical materials. A brief introductory session was provided to ensure that students were given the opportunity to become familiar with loading and using the material, and using the help screen provided. However, in order to ensure that the session did not influence the student evaluation of the courseware which was undertaken in subsequent sessions, no prescriptive guidance was given on how best to navigate through the courseware or on strategies for on-line note taking, nor were recommendations made on how best to use the system. Because of the manner in which the teaching of the subject is delivered, the CAL sessions were delivered in two semesters. In the first semester 32 postgraduate students used the CAL package having one lecture session replaced by use of the lecture 'equivalent' in CAL format. They also experimented with one unit of the CAL package which was designed to supplement instruction in practical classification. In the second semester the experiment was repeated with 30 undergraduate students using the same materials.

During the formative evaluation stage student use of the system was restricted mainly to those times when a timetabled lecture, seminar or practical class was scheduled so close observation of how students made use of the material was possible. However, exceptionally students requested and were permitted, to use the software independently (because of inability to attend a lecture or practical at a particular time). In such cases observation of use was obviously not possible but those students were encouraged to ensure that they completed a questionnaire immediately after use of the courseware and to attend the feedback sessions and when doing so to identify the fact that they had made independent use of the courseware.

Observation of use was conducted during laboratory based sessions each scheduled for one hour. During these sessions students were using the CAL courseware as either a substitute for a lecture (on 1 occasion for both postgraduate and undergraduate cohorts) or as a timetabled supplement to practical work (on 1 occasion for both postgraduate and undergraduate cohorts). Because of the limited capacity of the laboratory (12 computers) this entailed in total 12 hours of observation.

The researcher maintained a log of observations and noted in particular points at which intervention was required because of problems experienced or queries addressed by groups or individuals to either the researcher or fellow students. At this stage of evaluation a formal instrument for observation was neither used nor required. The purpose of the sessions were to ensure that any issues related to usability were logged rather than to observe the detailed manner in which students interacted with the courseware. Comments recorded in the log were generally concerned with technical issues related to how to use the courseware or comments on specific features which they found useful or problematic.

In all cases students appeared to be comfortable when using the system and no significant difficulty in the use of the courseware was evident. Two students (both postgraduate) required a great deal of assistance using the courseware – the nature of this assistance being technical support in performing elementary tasks such as using a scrolling window to view text, understanding the instruction to insert a formatted floppy disk into the A:/ drive and resizing windows which they had inadvertently changed. Students progressed through the material in a sequential manner and almost invariably activated any icons or hotwords which gave access to further extended explanations or diagrams. The rate at which students progressed through the material varied considerably at the extremes, one student completing a session (intended duration of 50 minutes) in 25 minutes and one student requesting and being permitted to take longer to complete her study of the same unit and completing it after 1hour 35 minutes.

10.2.2 Questionnaire on CAL prototype – Lecture Based Materials

A questionnaire was developed to allow students to provide feedback and express opinion on the CAL courseware prototype which had been developed in the first part of the research. (Appendix 5). The questionnaire consisted of two parts. Both parts required students to use Lickert type scales in their responses. The first part posed questions concerning the degree of clarity, usefulness and relevance of the information and ease of use of the package. The second part invited specific responses on usefulness of the different tools provided in the interface. The questionnaire was issued immediately following laboratory sessions in which groups of students had used the CAL materials. Students were not required to provide demographic data in order to maintain anonymity and allow students to express their opinions freely. A quantitative summary of the feedback was derived in order to provide an overview of the main issues which needed to be addressed. This is illustrated in Table 10.2. For questions which require a rating to be given responses have been broken down to show the separate ratings given by postgraduates and by undergraduates. An initial survey of the data derived from open questions showed that similar types of comment were being made by postgraduate and undergraduate students. Thus these open comments from both postgraduate and undergraduate students have therefore been merged in the analysis presented here in order to provide a clearer picture of student response to the design and use of the prototype. Comments were classified according to general theme and where the same type of concern was voiced by more than two students these have been these have been recorded in the Table 10.2.

Table 10.2 Feedback on lecture based materials delivered in CAL format

General Questions on use of 'lecture based' CAL package												
Question Posed	Number of students (n = 62)											
		1		2		3		4		5		
		PG	UG	PG	UG	PG	UG	PG	UG	PG	UG	
1. Was it clear to you why you were using the package?	Clear	8	15	7	11	8	2	7	2	2	0	Unclear
2. Did you find the package easy to use?	Easy	23	15	6	8	3	4	0	2	0	1	Difficult
3. Did you find the information appropriate for your course	Relevant	26	24	3	2	1	1	2	2	0	0	Irrelevant
4. Did you find that the information was presented in an interesting manner	Interesting	23	11	5	7	2	4	1	6	1	2	Boring
5. Specific Problems/ Notes	Not always clear why particular topics were being discussed in relation to the theme of the lecture (8 responses) Scrolling down the lecture window is irritating (19 responses) Would be useful to have a more extensive test at the end of the lecture (4 responses) Could be more colourful (2 responses) Sounds and music are irritating and not very useful (39 responses) Need more time to complete the lecture (2 responses) Need to be able to print out rather than just take notes (4 responses)											

Rating of usefulness of different tools								
Tool used	Number of students (n = 57)							
	Essential		Very Useful		Not very useful		Useless	
	PG	UG	PG	UG	PG	UG	PG	UG
1. Topic buttons to link directly to part of the lecture	24	17	6	9	0	1	0	0
2. Find function (to find all occurrences of a word)	0	2	2	4	14	11	14	10
3. Glossary	0	4	3	4	12	14	15	5
4. Further explanation/examples icon	11		13		5		1	
5. Mapping Tool	0	2	0	4	23	20	7	1
6. Short quizzes/tests	26	19	6	8	0	0	0	0
7. Note taking function	19		11		0		0	
8. Suggestions for other features	None							

Responses to the questionnaire are discussed in terms of the two sections of the questionnaire i.e. the general questions on the package and the questions which were related specifically to the type of tools provided in the user interface. Many of the issues coming out of the questionnaire survey were followed up later in Structured Feedback Sessions. (Section 10.2.4)

10.2.2.1 General Questions

Question 1

Was it clear to you why you were using the package?

Students, particularly at postgraduate level, appeared to have some difficulty in understanding why they were using the lecture based package. Investigating this point in more detail during feedback sessions with the students it was found that the problem centred around the presentation of the aims and objectives of the multimedia CAL lecture. While a general statement was given of the aim of the lecture it was not clear how different parts of the lecture contributed to this overall aim. Undergraduate students had less difficulty in this respect and this was less problematic for them as they had already completed a year of studies and were thus more confident in being able to make links between topics discussed in the lecture and other areas of the curriculum. In addition the structured feedback session with a group of undergraduate students also revealed an attitude amongst the learners that indicated that even if things did not appear to be entirely relevant that the importance of the topic would become more obvious as the course progressed. Given that the lecture based part of the CAL package was going to be tested using the postgraduate cohort it was decided that steps should be taken to make the aims and objectives and the relevance of the material being presented more readily apparent.

Questions 2 - 4

Did you find the package easy to use?

Did you find the information appropriate for your course?

Did you find that the information was presented in an interesting manner?

Overall the feedback from this part of the questionnaire demonstrated that there was a high level of satisfaction with the prototype system on both the part of the undergraduate and postgraduate students. Ratings of 5 or 4 were given in the Lickert scales indicating that the package was rated as being easy to use by 52 of the 62 students (84%), the information was appropriate and relevant (89%, 55 students) and the presentation was interesting (74%, 45 students).

Question 5

Specific Problems

Specific problems related were raised with respect to the use of a scrolling window to hold the lecture text. Again subsequent feedback from students indicated a marked preference for having small chunks of text placed on individual screens i.e. a screen based rather than a windows based approach. Four students commented that more extensive test material for the lecture would have been useful. Sound files had been included in the package in the form of short midi and wave files which were automatically activated by correct and incorrect responses to short test questions. In addition some brief 'voice over' commentary used to introduce the lecture. These were obviously felt to be inappropriate as shown by 39 (63%) of student comments. Other comments related to lack of time for use of the material, a requirement to be able to print the material, and the need for additional test material. Comments on use of colour were made but on discussion with students it was considered that this was fairly specific to individual student taste and overall there was a high level of satisfaction with the colours used in the interface design.

10.2.2.2 Tools used

A surprising finding was that students were not at all interested in making use of a map tool which was provided to demonstrate the links between topics studied and other areas of the curriculum. In discussion with students it emerged that they felt that the overall structure given by the lecture overhead was sufficient and they did not feel that the tool was useful. Likewise, as novice learners of the subject, they considered that the glossary was not a useful feature as the terms themselves were well defined in the text. The 'find' function, activated from a pull down menu was not used and again discussion with students confirmed that at their stage of learning about the topic this was not appropriate, although they did note that as a revision aid such a function would be useful. Other tools were all rated very highly with responses generally being that the tools to allow note-taking, jump directly to a particular topic, take a short quiz or activate further explanation or examples of the topic were essential or very useful.

10.2.3 Questionnaire on practical skills material

A similar questionnaire was developed to allow students to provide feedback and express opinion on the CAL courseware prototype for practical skills (Appendix 6). The same set of general questions was posed in this questionnaire as in the questionnaire on the lecture based materials but the section dealing with tools was modified to reflect the different tools which had been implemented for the practical courseware. The practical skills courseware questionnaire responses are presented below in Table 10.3.

Table 10.3 Feedback on practical skills based materials delivered in CAL format

General Questions on use of 'practical skills' CAL package												
Question Posed	Rating Given (n = 60)											
		1		2		3		4		5		
		PG	UG	PG	UG	PG	UG	PG	UG	PG	UG	
1. Was it clear to you why you were using the package?	Clear	17	16	7	7	3	3	2	2	1	2	Unclear
2. Did you find the package easy to use?	Easy	19	12	6	8	3	5	2	1	0	4	Difficult
3. Did you find the information appropriate for your course	Relevant	22	20	5	0	3	4	0	3	0	3	Irrelevant
4. Did you find that the information was presented in an interesting manner	Interesting	20	15	8	7	1	3	1	3	0	2	Boring
5. Specific Problems	More examples needed to try out (5 responses) Problem having to use the printed schedules as well (8 responses) Theory is not very useful - more practical examples (4 responses) More pictures needed (6 responses)											

Rating of usefulness of different tools								
Tool used	Rating Given (n = 62)							
	Essential		Very Useful		Not very useful		Useless	
	PG	UG	PG	UG	PG	UG	PG	UG
1. Topic buttons to link directly to part of the lesson	25	26	7	1	0	2	0	1
2. Short quizzes/tests	29	30	3	0	0	0	0	0
3. Examples	28	30	4	0	0	0	0	0
4. Note taking function	23	14	7	14	0	0	2	2
5. Suggestions for other features	Link to Electronic Dewey (3 responses) Random test with different kinds of examples (2 responses)							

10.2.3.1 General Questions

Responses to general questions showed high level of satisfaction with the CAL materials. Ratings of 5 or 4 were given in the Lickert scales indicating that the purpose for using the package was clear by 47 of 60 students (78%). The package was rated as being easy to use by (75%), the information was appropriate and relevant (78%) and the presentation was interesting (83%). Specific comments related to the need to add more test examples (5 responses) and to cut down the amount of theory (4 responses). Much of the practical based material was very descriptive of procedures, and feedback suggested that use of more images could make the material more interesting. Finally, several comments were made about the difficulty of having easy access to the printed schedules of classification using the program. The schedules of classification are bulky and in order to try examples and check responses it was necessary (because of physical limitation of space around the workstations) for students to access the schedules in a separate room and return to the laboratory to check their answers. Ideally an on-line version of the schedules which could be accessed from within the program would have dealt with this problem. However, because of the complexity of the programming involved and potential difficulties with copyright it was not possible to make a direct link between the Electronic Dewey programme (available on the University network) although this was suggested as an additional feature which would be useful. The desirability of the link was obvious and could have contributed towards the development of a fully constructivist environment for learning practical skills but as noted previously this was not the objective of development.

10.2.3.2 Tools used

All of the tools provided in the CAL materials designed for development of practical skills were rated as being essential or very useful. The only concern about which comments were made related to the need to include more practical examples and test examples.(3 responses). Suggestions for additional tools were to include a link to an electronic version of the schedules but as noted above this was not practical within the scope of the research undertaken here. A further suggestion was to include a feature to allow a random sample of test examples to be generated.

10.2.4 Structured Feedback Sessions

Timetabled seminars, typically held the week following the use of the CAL packages, were used to provide opportunities to elicit feedback from all students who had completed the questionnaire on their various perspectives and experiences of using the courseware. The feedback sessions were structured around issues which had been derived from an analysis of observation of use and the analysis of the student questionnaire. The main issues that were discussed related to:

- Use of sound files in the courseware – it was resolved that these were not helpful
- More extensive use of graphics – though it was recognised that these were not particularly helpful in terms of supporting the understanding of the information provided, a majority of students felt that they 'made the session more interesting' and should be used more extensively
- More support with practice examples – there was a general feeling that there should be more practice examples given to permit students more time to try out their skills in practical classification
- Clarity of aims and objectives of the 'lecture session' – the discussion with students revealed that the crux of the problem was that while they were given an overall statement of the aim of the lecture they also required more specific guidance on objectives which would explain specifically what they were expected to learn
- Break the 'lecture' information up over more than one screen – in the prototype system the text for a full lecture was presented in one scrolling window – the student could 'jump' to a specific point in the text by highlighting the topic they wished to study (by clicking on the appropriate button from a choice presented on the left hand side of the screen). Contrary to what might be expected from the discussions in the literature which advocate that designers should avoid simple 'page turning' devices for progression through material the students wanted to have the lecture delivered in a number of discrete pages with the facility to go to a particular section and 'click through' the pages in that section rather than be simply be directed to the appropriate point within the lecture.

In addition students engaged in discussion on issues such as problems with navigation, very specific problems with clarity of some of the examples provided, difficulties in knowing how to take notes, and problems of distinguishing important points from less important ones. These issues were related more to formative assessment of the student learning and are discussed in detail in that section of this chapter (Section 10.3). Surprisingly it emerged that despite observation of use two students had experienced considerable difficulty with the use of the system and on describing their problems it appeared that this was certainly because of hardware problems (in both cases because of a malfunctioning A:/ drive on the computer being used). This underlines the importance of using a range of instruments to assess student performance and attitudes to use of technology in order to ensure that the context in which students are working and reporting on their experience is fully understood.

Finally the sessions also allowed time for informal responses and concerns of a more general nature. Often these ranged far outwith the objectives set for the structured feedback but they were nonetheless interesting and worth reporting. In this context, with the postgraduate cohort, there was an interesting discussion on the overall rationale for using CAL. Some students were very much of the opinion that this was 'the wave of the future' and that as we moved into an age when increasingly technology dominated all areas of society it was inevitable that in education there would be more use of computers to 'replace' teachers. A number of students (12 of 60) were violently opposed to this view and argued that they saw lectures as the central part of their study (whilst conceding on further discussion with their colleagues that there were some subjects in which they left the lecture theatre feeling that a simple printed handout would have delivered the same information with 'far less pain'). On prompting to say exactly what it was about lectures which they felt very strongly were missing from the courseware they responded that jokes and anecdotes which pepper lectures and the occasional point at which the lecturer strayed completely from discussing the subject but illustrated a more general point about how to 'get through' the course or even 'get through life' were examples of what made the lecture format for interesting. An interesting discussion also took place about the motives of teaching staff for using computers in teaching. The majority of students appeared to be of the opinion that these motives were altruistic and that the lecturers were driven by a desire to improve quality of education. A small but vocal minority, however, were firmly of the opinion that this was simply a way in which lecturers could 'make life easier for themselves' and lessen their contact with students.

As noted above these discussions were not central to the purpose of formative evaluation of the system. However, they raise an interesting point about the perspectives from which evaluation is often discussed in the literature. There is some discussion about specific learner attributes and a good deal more discussion relating to staff attitudes and concerns about introducing technology into teaching but often in such studies the student is seen as the object of study and little is reported concerning the manner in which students have reacted to the learning environment. Discussions in the structured feedback confirmed the view developed in the first part of the thesis that it is necessary to focus more closely on the concerns of students and the epistemic beliefs which they hold about their own learning and how the use of technology is viewed.

10.2.5 Tests of Interface by Students enrolled on the module 'Multimedia Technology and Applications'

In keeping with the discussion in the literature on the importance of evaluating courseware in authentic settings (see Chapter 8), even at the formative evaluation stage the CAL prototype was tested mainly by postgraduate and undergraduate students for whom the system was intended as a teaching aid. However, an exception to this was that in addition the prototype was used as the object of study in a taught module on Multimedia Technology and Applications. The rationale for this was that students on that module (also taught by the researcher) were learning skills which involved the assessment of multimedia user interfaces. They were thus in a position to be able to comment upon and suggest refinements to the interface even though they did not necessarily understand the subject content. Participants in this module (delivered to third year undergraduates in Information and Library Studies and Publishing Studies) were required to comment critically on the design of the system and in laboratory sessions which were an integral part of the module students used individual copies of the system experimentally and could change and add new features. Students were given assistance to make changes and encouraged to discuss these in small group work. This methodology can be seen to accord very well with the principles of iterative development and allowed practical experimentation and testing of a number of suggested improvements to the interface (notably with respect to changing the page layout, graphics and colour).

The findings from these tests are discussed when examining changes to the prototype in Section 10.2.6.

10.2.6 Changes to prototype in response to student feedback

During the latter half of the academic session 1996/7 more teaching material was added to the CAL courseware package and significant issues which had arisen from formative feedback of the prototype courseware were addressed.

In response to the observation of use, questionnaire feedback and structured feedback the following changes were made to the prototype:

Lecture based materials

- all sound files were removed
- the 'lecture' interface was redesigned to 'chunk' parts of the lecture over a number of pages (to obviate the need for a scrolling screen).
- the interface to include an introductory page which outlined specific aims and objectives for each part of the lecture was changed(this change is illustrated below in Figure 10.1)
- more test material was added

It was decided that print facilities should not be implemented as the researcher was interested in the ability of students to use the material on-line.

Practical materials

- more test materials were added

There was only one change which was deemed necessary for the practical based materials. Perhaps because users had more flexibility over the sequencing of the instruction there was not as much comment on the arrangement of the material itself nor the means of accessing it. The only real issue appeared to be the quantity of material provided.

Because of the complexity of implementing changes and the very small number of students who suggested that they were required, changes to permit randomly generated tests were not implemented. This also applied to a suggestion to allow integral access to online schedules which would, in any case, have been problematic because of copyright restrictions governing the use of the schedules of classification.

In addition, in response to comments, suggestions and experimentation with the system by students enrolled on the Multimedia Technology and Applications module, changes which were made to the prototype to:

- a facility to allow students to see clearly which topics they had already studied was added (The button activating that topic was dimmed)
- many of the bitmap graphics were removed and more use made of line graphics and clip art (scanned images were proving to be slow to load and because of the quality of the scanner used and the need to manipulate the size of the graphic the quality of the image displayed was sometimes rather 'blurry')

A print out of the introductory session for the CAL courseware designed to replace lecture delivery is provided in Appendix 7.

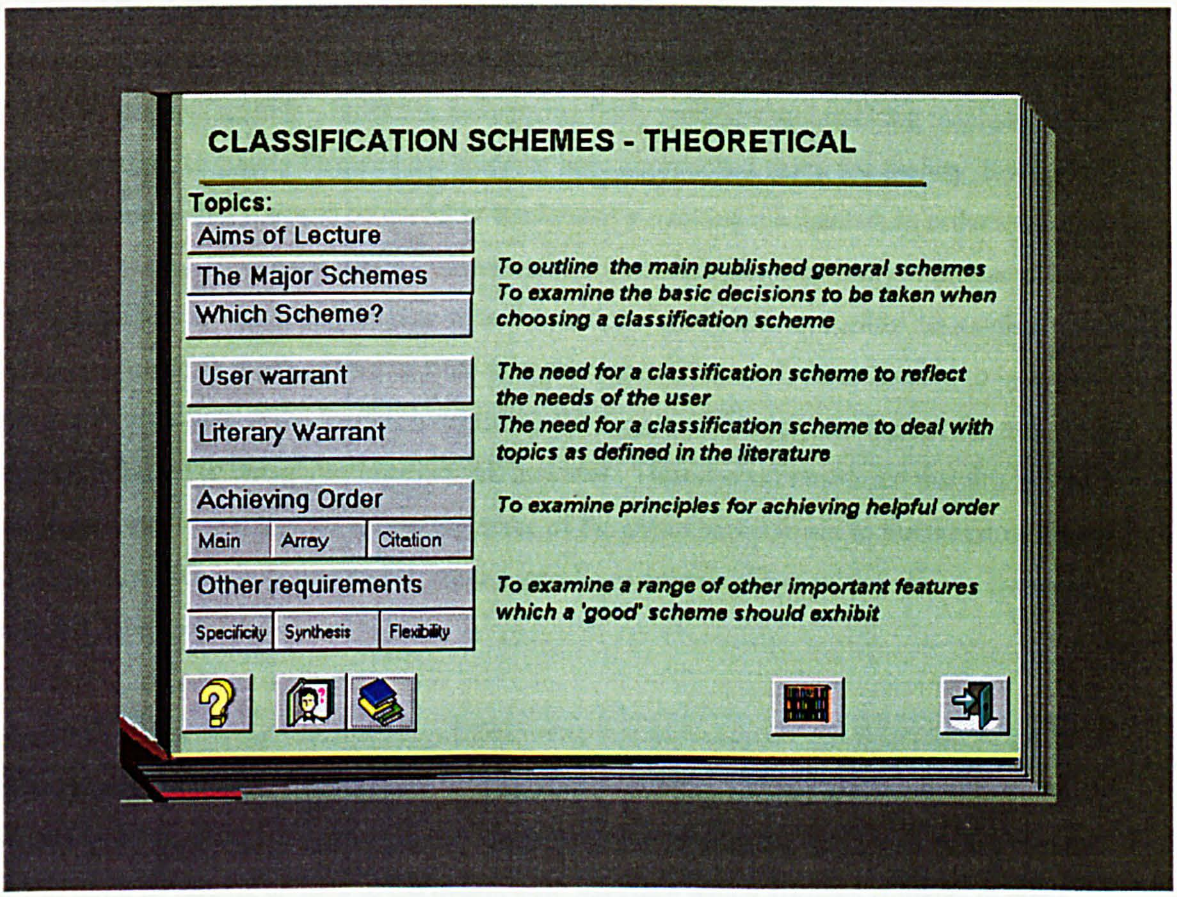

Fig. 10.1 Modification to prototype version of Lecture Based CAL programme Opening Screen for Lecture 3

10.2.7 Other changes to the prototype

Iterative prototyping of an application should not only take into account the potential for implementing change instigated at the behest of potential users but should also incorporate changes which may be instigated because of self reflection and examination of objectives by the developer.

It was noted whilst observing sessions during which students made use of the courseware that it was difficult to gain more than a superficial impression of how students were navigating their way around the different screens of information. A significant factor when considering implementing CAL systems is that multimedia CAL packages themselves can prove to be very effective meta-teaching aids – most can incorporate fairly sophisticated tracking mechanisms to allow the lecturer to clearly discern how students have approached using the facility. It was, therefore, decided that it would be useful to implement a tracking mechanism in order to be able to provide a more accurate description of the extent to which students actually exercised control over the sequence in which they engage with instructional materials. A further reason for developing a tracking mechanism was that, as discussed in Chapter 4, there seemed to be some contradictory evidence in the literature regarding the degree of freedom or 'learner control' which students exhibit when using multimedia CAL material. Thus it was considered that this would prove to be a useful mechanism for testing some of the assumptions made in the literature about the manner in which navigation and 'learner control' are enhanced by multimedia CAL systems. (see 10.3.2.4 below).

Another important change made to assist subsequent evaluation was the implementation of a facility to allow users to provide comments directly and anonymously whilst using the system. This was done by adding an icon to the courseware interface which allowed students to make comments which would be saved automatically in a file on the hard drive of the computer on which they were working. These files from the machines on which the CAL courseware was running could then be examined periodically and a file of user responses built up. While tracking facilities allow the researcher to covertly examine the manner in which a student makes use of the system it is also important to ensure that users are aware that there are direct mechanisms to provide feedback to the system designer or course tutor. Explicit channels of communication need to be made available to allow the student to interact directly and provide on-line comments and criticisms of the system. This facility allowed students to comment on the learning materials and request further explication or expansion of points and such comments could be responded to during feedback sessions or followed up in a person e-mail to the student from the course tutor. During the formative evaluation this also allowed students more direct and immediate involvement with the tutor rather than feeling that comments or criticisms had to be aired in structured meetings. Students could therefore feel that they were engaging in a dialogue in which their own ideas were important and could contribute to course delivery.

10.2.8 Tests on impact of using more than one medium

Finally as noted in the introduction to this chapter it was decided that the prototype could be used to test certain contradictory statements which were apparent when reviewing the literature. The discussion in the literature on the benefits of multimedia CAL showed a somewhat inconsistent set of results when considering the value of presenting information in more than one format. (See Chapter 4). In particular there was no evidence that, specifically in terms of evaluation of CAL interfaces, an empirical approach had been taken to examine the value of using sound, graphics and text to complement one. However, an assertion has often been made in the literature is that appropriate graphics will act as an aid to learning. In order to investigate this further a simple test was conducted which involved two groups of students (27 students in each group) using alternative CAL presentation formats. Students were randomly allocated to one of two groups and the group composition was made up of equal numbers of undergraduate and postgraduate students.

The test involved a practical skill in classification using the Dewey Decimal Classification Scheme. This scheme organises documents using a broad range of ten divisions of knowledge and specific subjects are given classmarks within these divisions. Basically the scheme subdivides knowledge into ten divisions as shown in Table 10.4.

Table 10.4 Subdivisions of the Dewey Decimal Classification Scheme

CLASSMARK RANGE	SUBJECT
000	Generalia
100	Philosophy and Psychology
200	Religion
300	Social Sciences
400	Language
500	Pure Sciences
600	Applied Science. Technology
700	The Arts, Recreation and Sports
800	Literature
900	History, Biography, Geography

An useful skill in practical classification is to be familiar with the schedules of classification to the extent that when asked to classify a document on a particular topic students can readily identify which of the ten main classes is the most appropriate for a particular subject.

One group of 27 students (Group A) used part of the multimedia CAL package which had been developed to teach practical classification, and incorporated images and text to illustrate the main classes used by the Dewey Decimal Classification Scheme[1]. (See Figure 10.2 which shows an example of the screen layout for one of the ten subdivisions of the classification scheme). A second group of 27 students used the same package, but the graphics were removed and the examples given of subjects which were allocated to particular classes was presented only in text format. (See Figure 10.3 which shows an example of the text only screen layout). All students were then required to complete a test which involved accurately placing 25 subjects into the appropriate main class discipline by either recalling or inferring which class was used for a particular subject. (Appendix 8 provides the Dewey Decimal Classification Scheme general layout showing the broad categories into which students should have allocated the subjects).

[1] The issue of the use of sound was not investigated as previous tests when formatively evaluating the courseware had conclusively determined that this was not a feature which students found helpful when using the courseware.

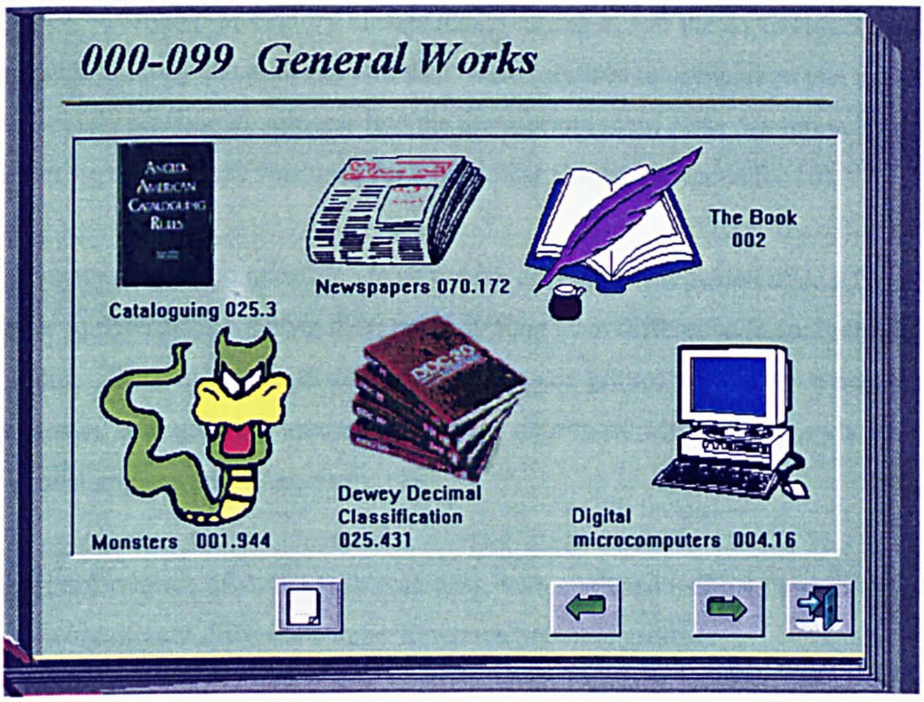

Figure 10.2 Example screen showing text and graphics presented together

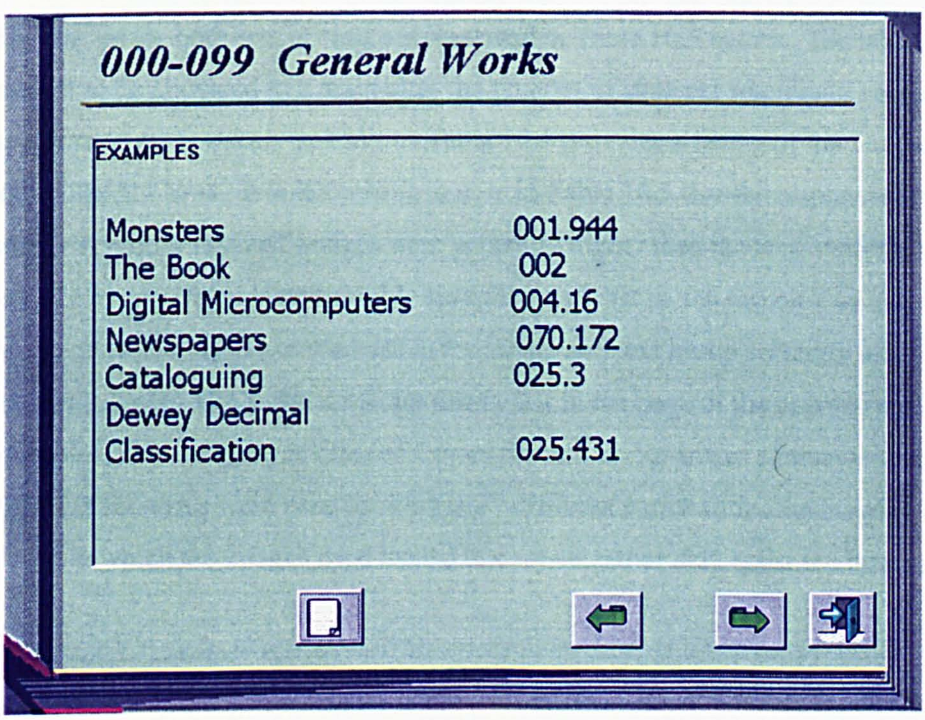

Figure 10.3 Example screen showing text only layout

During scheduled laboratory classes the 25 Group A and the 25 Group B students were given 30 minutes to study the material and then were required to complete a test which involved accurately placing 25 subjects into the appropriate main class discipline by either recalling or inferring which class was used for a particular subject. (Appendix 10).

The test of ability to accurate identify main classes was repeated after a five month period in order to determine whether there was any long term difference in student performance in this type of task. The same students divided into the same groups were given a new set of 25 subjects was presented and again the student task was to determine which of Dewey's ten main classes would be most appropriate. (Appendix 11)

The performance of students in both tests were analysed using a t-test to establish whether there was a significant difference in performance between groups.

Results

The results for both sets of tests are presented in Table 10.5 below. The table lists for each subject to be allocated to a main class the number of students who could correctly identify the appropriate main class. In addition Table 10.6 provides a listing of the test performance of individual students. It is interesting to note in Table 10.5 that the responses from students who could view both text and images were generally higher than those of students who only read the text. However, there is one notable exception and that is the response to question 3 (Flags) where considerably fewer students in the image and text group correctly identified the main class for this subject. The explanation for this is that in the page of the courseware illustrating examples of the languages class of Dewey the text and graphics courseware version used flags of different countries were used to 'illustrate' different nationalities/languages. This was obviously a case in which the images used tended to confuse rather than assist the learner.

TABLE 10.5 ABILITY OF STUDENTS TO CORRECTLY ALLOCATE SUBJECTS TO DC 20 MAIN CLASSES

		NUMBER OF CORRECT RESPONSES FOR EACH SUBJECT				
		IMMEDIATE POST-TEST		DELAYED POST-TEST 5 MONTHS LATER		
	Subject to be classified	Number of students correctly identifying class			Number of students correctly identifying class	
		Group A N=27 Text+Image	Group B N=27 Text only		Group A N=27 Text+Image	Group B N=27 Text only
1	Law	24	20	1. Christianity	23	22
2	Languages	20	20	2. Philology	21	24
3	Flags	10	17	3. Travel	18	22
4	Rugby	18	15	4. Tennis	22	17
5	Geography	18	19	5. Geology	24	23
6	Biology	22	20	6. Botany	23	26
7	Chemistry	18	15	7. Education	20	20
8	Music	24	22	8. Opera	18	18
9	Mathematics	25	25	9. Algebra	23	24
10	Economics	20	17	10. Sociology	15	16
11	Judaism	22	14	11. African History	23	23
12	French	18	10	12. Latin	19	19
13	Prayer	16	15	13. Meditation	20	19
14	Psychology	18	12	14. Paranormal phenomena	20	18
15	Travel	17	12	15. Horse Racing	19	19
16	Card games	22	18	16. Architecture	26	24

TABLE 10.5 (continued) ABILITY OF STUDENTS TO CORRECTLY ALLOCATE SUBJECTS TO DC 20 MAIN CLASSES

NUMBER OF CORRECT RESPONSES BY STUDENTS

IMMEDIATE POST-TEST | **DELAYED POST-TEST 5 MONTHS LATER (N=54)**

Subject to be classified		Number of students correctly identifying class			Number of students correctly identifying class	
		Group A N=27 Text+Image	Group B N=27 Text only		Group A N=27 Text+Image	Group B N=27 Text only
17	Athletics	26	15	17. Sport	26	22
18	Politics	26	20	18. Commerce	23	23
19	Medicine	23	20	19. Surgery	26	22
20	Physics	27	23	20. Pathology	25	22
21	English Literature	20	11	21. French Literature	25	24
22	Horse Racing	19	14	22. Physiology	27	26
23	Poetry	20	15	23. Plays	22	22
24	Italian Grammar	17	13	24. English Grammar	22	20
25	Ice skating	18	15	25. Chess	20	21
	TOTAL	508	417		550	536

TABLE 10.6 ANALYSIS OF PERFORMANCE IN TESTS BY INDIVIDUAL STUDENT

IMMEDIATE POST-TEST **DELAYED POST-TEST 5 MONTHS LATER**

			Student Overall Score in test (max = 25)					Student overall score in test (max = 25)			
Students N = 27			GROUP A Text + Image	GROUP B Text only				GROUP A Text + Image	GROUP B Text only		
1			18	14				21	20		
2			21	16				21	18		
3			17	17				18	21		
4			21	17				18	19		
5			21	16				22	20		
6			25	20				23	19		
7			18	18				19	23		
8			23	18				20	20		
9			11	14				23	22		
10			14	10				17	15		
11			23	22				23	25		
12			13	14				18	17		
13			17	13				15	18		

IMMEDIATE POST-TEST **DELAYED POST-TEST 5 MONTHS LATER**

			Student Overall Score in test (max = 25)					Student overall score in test (max = 25)			
Students N = 27			GROUP A	GROUP B				GROUP A	GROUP B		
14			19	18				15	13		
15			15	7				16	18		
16			18	14				25	22		
17			23	19				21	22		
18			24	22				23	20		
19			13	10				23	20		
20			19	12				20	19		
21			22	18				25	23		
22			24	20				25	24		
23			22	18				21	20		
24			15	13				18	19		
25			12	7				20	20		
26			23	20				19	17		
27			17	10				21	22		
			508	417				550	536		

The results were analysed using a t-test to establish whether there was any significant difference in performance in the tests between students who had accessed the material with text and graphics and those who had simply been given text. The results of the analysis conducted using SPSS (Statistical Package for the Social Sciences) are provided below in Table 10.7 and Table 10.8. below.

Table 10.7 T-Test - Comparison of performance of using of Text and Graphics interface (or Text only options (Immediate post test)

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
Score	Using Text and Graphics	27	18.81	4.10	.79
	Using Text Only	27	15.44	4.22	.81

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Score	Equal variances assumed	.009	.926	2.979	52	.004	3.37	1.13	1.10	5.64
	Equal variances not assumed			2.979	51.955	.004	3.37	1.13	1.10	5.64

As can be seen from Table 10.7 the results demonstrate that there was a highly significant effect in the immediate test of student performance (p = 0.004) and students who had access to text and graphics performed significantly better that those who only accessed the text only display.

Table 10.8 T-Test - Comparison of use of Text and Graphics or Text only options (Delayed Post Test)

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
Score	Using Text Only	27	19.85	2.66	.51
	Using Text and Graphics	27	19.63	4.72	.91

Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Score Equal variances assumed	2.340	.132	.213	52	.832	.22	1.04	-1.87	2.31
Score Equal variances not assumed			.213	40.985	.832	.22	1.04	-1.88	2.33

Examining Table 10.8, however, it can be seen that the longer term impact on student performance was not significant ($p = 0.832$) and in the delayed post test the performance of both groups of students was comparable, average scores for both groups being 19.85 and 19.63).

It appears that learners benefit considerably from being able to link graphics with text in order to aid recall. The fact that there was no significant difference between groups on the delayed post test indicates that whilst the effect is significant in the short term it is likely that the effect is swamped by subsequent exposure to numerous examples which are provided in class to demonstrate the use of the classification scheme and the development of a greater awareness of the structure of the classification scheme through further study and practice both in class and as a result of independent learning.

10.3 Formative Evaluation of learning using CAL

In testing the prototype, as described above, the main aim was to ensure that the design of the courseware was satisfactory and the courseware was easy to use. However, when considering formative evaluation from the perspective of how users would learn from such a system, it was much more important to focus on how the system was used and to look in detail at the manner in which individual learners interacted with the courseware. As discussed in Chapter Eight, this necessitates a phenomenographic approach to formative evaluation in order to gain a rich picture of the manner in which students use the material. Attempts to explain any features of the manner in which students interact with the courseware should be done in terms of examining their experience in use of the courseware without pre-judging this against any 'ideal' mechanisms for how they should learn when using it.

As in other areas of research, the ways in which phenomenographic data are gathered requires a very careful analysis of available instruments for recording accurate information. Attendance at an evaluation workshop which was a preliminary part of the programme for the 1994 World Conference on Educational Multimedia and Hypermedia in Education (Reeves, 1994) was very useful in this respect. The evaluation workshop was led by Professor Tom Reeves from the University of Georgia and as well as leading a discussion on the effectiveness and problems of evaluation of courseware, Reeves also provided participants with useful practical experience on using and modifying a range of evaluation instruments. Subsequently these have been made available on the Web and collectively they provide a very useful starting point for developing a programme of evaluation. Again, the work of the TILT group in Glasgow was also found to be very pertinent. (It should be noted, however, that these methods were not framed with the intention of supporting a phenomenographic approach to use of CAL). Some of the methods of investigation which had been tested by this group were modified and applied to the current research. As in the first part of the formative evaluation these included observation of use, the use of student questionnaires, and group feedback sessions. In addition feedback was supplemented by the use of confidence logs in order to capture student perceptions of how confident they were that they had achieved the learning objectives set in the courseware. In addition the implementation and use of automatic tracking mechanisms supplemented external observation of how students interacted with the learning materials.

Thus the second part of the formative evaluation stage was to apply tests which were more directly focussed on:

- investigating in detail the manner in which students interacted with the CAL courseware

and

- examining student attitudes and concerns with respect to using CAL

In order to achieve these objectives the investigation of use of the courseware had to be much more sensitive to the manner in which students reacted to use of the CAL material. As a consequence it was important to ensure that learners were being observed in an 'authentic context'. Thus at this stage of the research undergraduate students used the CAL materials which were designed to supplement delivery of practical skills and postgraduate students used the CAL materials designed to replace lecture material. Significantly also the students using the courseware at this stage were introduced to using them as an integral part of their studies and were encouraged in the view that the courseware session was not an 'experiment' but an important means of gaining the knowledge or skills they needed as part of their course of study. In all cases the CAL packages were used in the laboratory as part of scheduled classes on the topic and the researcher was present.

10.3.1 Formative Evaluation of 'CLASSICAL' Lecture Based CAL materials

Postgraduate students made use of the lecture based CAL material. Rather than deliver a lecture on the subject of the general requirements of a classification scheme in the third and fourth week of their course on classification, laboratory based sessions were arranged in which the students studied the same content but delivered using the CAL package. Because of the restriction on computers in the laboratory used, this involved three one hour sessions. Each student attended a one hour session. Although thirty two students were registered on the course only twenty nine students attended the CAL session. It was established by the lecturer that students who did not attend did not do so because of the format of the lesson but because of medical problems or general lack of motivation.

10.3.1.1 Observation of Use

Observation of use at this stage was conducted by the researcher in order to determine whether any patterns of unusual behaviour were evident or to assist students who were experiencing considerable difficulty in understanding how to use the packages. No attempt was made to intervene at this stage nor to query students about why they were adopting a particular approach although as noted below at one point it was felt that students did modify their behaviour because they were being observed. An 'Anecdotal Record Form' (Reeves, 1994) was used to record problems or issues which arose during the course of any laboratory session. (The form is included in Appendix 12). This involved the researcher in noting only the observed behaviour and not attempting to provide interpretation of the behaviour or ascribe reasons for it. A summary of these issues was later made and at that point patterns of behaviour were analysed and possible explanations recorded. This provided some useful material for triangulation with data which was derived from questionnaire responses and from student feedback sessions.

Observation of students at this stage showed a range of different approaches to using the materials. In one laboratory session a group of five students engaged actively with the material and, although the package had not been written for group work, formed a small group and used the fact that any part of the lecture could be easily accessed to discuss what was meant by particular points (or at least what their understanding was of particular points). Most students worked individually and methodically and followed the structure of the lecture which was implicit in the way in which the topics were arranged on screen. The majority of the students took copious notes using the note taking facility provided whereas a small number of others (3 students) were observed to use pen and notepad to perform the same function (although clearly aware of the notepad option which allowed them to take notes online). In separate sessions six students were observed to move very quickly through the entire lecture content prior to returning to the main menu screen and then working systematically throughout the lecture. In the lecture based material the short quiz could only be accessed from the main menu screen and two students were observed to attempt to take the quiz prior to studying the material. They quickly changed this strategy and returned to reviewing the teaching material. (It was, however, felt that this may have been a consequence of the students feeling that they were being observed and feeling some embarrassment at the fact that they were obviously not coping with the assessment).

Within the course of the three sessions delivered in the first week of use of the CAL materials two students left the laboratory session after only ten minutes without explanation. When subsequently questioned by the lecturer one asserted that he felt that it was pointless trying to do the session because computers simply "didn't work for him". The student obviously had a deep-seated conviction that any attempt he made to use technology would inevitably be unsuccessful. The second student explained that he was having great difficulty in understanding the subject itself without it 'being made more complicated by computers'.

10.3.1.2 Questionnaire

A questionnaire was issued to all students and they were required to complete it prior to the end of the laboratory session in which they used the CAL materials. (Appendix 13). As with the questionnaire to assess the functionality of the courseware it had two sections. The first was intended to confirm usability (Table 10.9) and the second was to uncover information about attitudes to use and thus targeted at study preference (Table 10.11).

Table 10.9 General Questions on use of 'lecture based' CAL courseware

Question Posed	*Responses (n = 27 reflecting 2 non-returns)*						
Was it clear to you why you were using the package?	Clear	24	0	1	0	0	Unclear
Did you find the package easy to use?	Easy	17	5	2	2	1	Difficult
Did you find the information appropriate for your course	Relevant	20	3	0	3	1	Irrelevant
Did you find that the information was presented in an interesting manner	Interesting	16	3	6	1	1	Boring
Specific Problems Notes	One student reported a problem which was specifically concerned with the computer which he was using – the graphics card was faulty and the screen resolution as a result was very poor. Not enough time to complete using the material (2 responses)						

The responses given shown in Table 10.9 demonstrate that in general there was no problem with the usability of the CAL materials and this was expected given the extensive testing of the prototype system. Student response was generally positive. The results show that students had a firm grasp of why they were using the courseware and generally students found the courseware easy to use, relevant and interesting.

It was considered that a comparison of student attitudes to the value of the 'online lecture' could be made with the attitudes to a traditional lecture by modifying the first part of the questionnaire. Thus, the first part of the questionnaire only was amended and the modified version was delivered to students at the end of a 'traditional lecture'. The results are presented below (Table 10.10)

Table 10.10 General Questions on a traditional lecture

Question Posed	***Responses (n = 30)***						
Was the purpose of the lecture clear to you?	Clear	26	2	2	0	0	Unclear
Did you find it easy to follow the lecture content and structure?	Easy	19	6	4	1	0	Difficult
Did you find the information appropriate for your course?	Relevant	20	5	5	0	0	Irrelevant
Did you find that the information was presented in an interesting manner?	Interesting	15	4	8	2	1	Boring
Specific Problems Notes	Lecture is too fast –not enough time to take notes (4 responses) Overheads not always easy to read (2 responses)						

An analysis of the general comments on the CAL system taken in conjunction with an analysis of the comments made on a 'traditional' lecture show a marked similarity. Although the responses were for different topics the same students provided roughly similar feedback to questions which were designed to elicit the same information concerning clarity, ease of use, relevance and interest. This corresponds with the view expressed in the literature that in comparative studies of lectures and courseware the most common reported finding is that there are no significant differences.

The second part of the questionnaire was devoted to gaining feedback on study preference and use of the CAL system. The responses to this part of the questionnaire are given in Table 10.11

Table 10.11 Questions related to study preference and learning

Question	*Responses (n=29)*					
Do you feel the CAL package has covered the aims and objectives for the 'lecture' ?	Yes	22	Partly	5	No	2
Reasons provided for response to Q 1.						
Do you feel you can learn more or less easily using the CAL package than during a lecture session?	Less	9	Same	14	More	6
How would you rate your overall attitude to learning using CAL packages?	+ve	10	Neutral	14	-ve	4
Would you be happy to have your entire module delivered using CAL materials rather than attend formal lectures ?	Yes	3	Unsure	12	No	14
Would you like to see CAL packages made available for other parts of your course?	Yes	11	Unsure	10	No	8
Give an example or examples of what you liked best about learning while using the CAL package	Always reminded about point of different parts of the lecture (4 responses) Able to go at my own pace (10 responses) Notes were much more accurate (4 responses) Easier to understand (2 responses)					
Give an example or examples of what you liked least about learning while using the CAL package	Having to read long passages of text (3 responses) Not enough pictures (3 responses) Too difficult to concentrate in the laboratory (3 responses) Not enough time to take notes (4 responses) Not enough time to get through everything (3 responses) Too much work compared with lecture (5 responses)					
Other Comments	Much prefer to listen to a lecture rather than read computer screens (4 responses) Not as much fun as the lectures (7 responses) Boring but then so are lectures (2 responses) Harder to know what was really important (3 responses)					

As can be seen from the table a very mixed set of responses were recorded when considering questions relating to study preference. Overall there was no evidence of a strong preference for either the traditional lecture or the CAL based lecture though it should be noted that a sizeable minority of students recorded that they felt they learned less easily using the CAL package. Only 4 students reported that they had a negative attitude towards use of CAL but a significantly higher percentage were not happy about the idea that the whole module might be delivered in this format and the same percentage felt equally strongly that it was not appropriate for other modules. It was felt that this re-inforced the point made in the literature concerning levels of evaluation. As was noted in Chapter Eight it is important not to make generalisable conclusions about the efficacy of computer assisted learning approaches when dealing with studies which are specifically designed to evaluate CAL at a particular level. Thus in this case, although it could be argued that students are reasonably content to have a particular lecture delivered using CAL, they would obviously be reluctant to see the method extended to covering the entire module.

The most significant point in favour of using CAL was that students could work at their own pace. It was interesting to note, however, that because of time constraints on use of the system caused by laboratory scheduling, a number of students felt that they did not have enough time to study the lecture completely. This re-inforces the point made in the evaluation framework in Chapter Eight concerning the influence of contextual issues on evaluation. Two students commented specifically that they felt that lecture material was easier to understand when delivered using CAL format and this may have been because of the constant assistance and re-iteration of the structure and objectives of the lecture (noted by 4 students). Note taking is an important activity in lecture based study and it was interesting that whilst 4 students commented favourably on this aspect because they felt their notes were more accurate when taken from the CAL material, an equal number of students commented adversely that they did not have sufficient time to take full notes. Other problems noted concerned the laboratory environment itself, which could become quite noisy particularly because some students took the opportunity to work collaboratively. Comments on having to read too much text and the need to introduce more pictorial material were considered to be more directly concerned with the interface rather than being informative about the type of learning taking place but, taken in conjunction with open comments which indicated preferences for listening to lectures (4 responses) and responses which indicated rather surpassingly that lectures were 'fun' (7 responses), may indicate that these were comments which were directed more at a preference for a particular mode of study rather than simply indicating a desire to modify the volume of content and presentation style. It was also interesting to note that in open comments a number of students indicated that the CAL package involved them in more work. Given that the same volume of material was used as in a 'traditional' lecture this may be more indicative of the fact that students were having to take more active responsibility for acquiring and processing the material rather than simply accepting what was given. This additional processing overhead is also evident in the comments made that it was harder to determine what was really important and what was less important when using the CAL materials.

10.3.1.3 Confidence Logs and Structured Feedback Sessions

Feedback sessions were organised in the week following use of the courseware by students and the approach to gaining structured feedback was to provide a short list of questions which were designed to engage students in discussion of the CAL materials and encourage them to reflect on their own learning and on their attitudes towards using computers in teaching. As with the formative evaluation of the functionality of the prototype, the themes which prompted the initial questions arose out of the feedback given in the questionnaire and out of the observation of how students used the materials In addition, students were encouraged to discuss any points which they felt were important in explaining the impact that using the courseware had on their attitude to study and strategies they adopted when learning.

A wide range of responses and attitudes were apparent in the questionnaire and it was decided that the feedback session should revolve around two specific questions which appeared to represent recurring themes in responses, these being:

- Is a CAL based lecture as good as a face to face 'traditional' lecture?
- What is the best way to use material delivered in CAL format?

In order to prompt students to consider what they had learned and how well they had learned they were asked to complete a confidence log prior to the start of the open discussion. These logs are designed to give learners an opportunity to record the degree to which they perceive they have attained the learning objectives of the courseware. They were originally developed by the TILT group and devised with the intention of providing instructors with quick 'snapshots' recording student progress. The context in which they were used in the research reported here was somewhat different. The main purpose of the logs was to provide a tool for the learner to record confidence in having met learning objectives and to encourage reflection by the learner on the value of the courseware in delivering the learning objectives. By firstly asking students to reflect on their learning in this way it was possible to structure the discussion to ensure that those learners who felt they were not confident about their achievements were given ample opportunity to explain whether they felt this was a function of the system used for teaching or of their own approach to learning.

Confidence logs issued to students at the start of the feedback session and analysed subsequently showed a very high level of confidence by students that they had successfully mastered the main objectives of the courseware. (Table 10.12). Discussion with students confirmed the overall impression of a high level of confidence in students having understood the main points which were presented in the courseware.

Table 10.12 Confidence Logs completed by students

Learning Objective	*Number of students confident of achieving the stated objective (n = 29)*
Know what the major published classification schemes are and what their strengths and weaknesses are with respect to subject coverage	23
Understand why and when it is important to classify bibliographic collections	29
Define what is meant by user warrant	23
Define what is meant by literary warrant	24
Describe methods of achieving order in bibliographic classification schemes	20
Clearly distinguish main (or macro order) and order in array (micro order)	20
Understand what synthesis is in relation to use of a bibliographic classification scheme	26
Understand what flexibility is in relation to use of a bibliographic classification scheme	25
Define the term specificity	27

Discussion, therefore was not focused primarily around whether students had learned as it was apparent to most participants in the discussion that useful learning had certainly taken place. However the question of whether CAL based lectures were as good as 'traditional' lectures provoked a variety of interesting responses. Generally most students considered that although the CAL based material was useful it did not completely replace the lecture. Students found it much harder to identify why specifically this was the case. It was suggested that one important feature which was not present in the lecture based material was a sense of relative importance of the different parts of the text and that this was often done in traditional lectures by repetition of important issues. It was further noted that the CAL material was not as interesting because anecdotes, which peppered the lecture presentation were not included in the CAL material, although it was also agreed that these would not be very effective in a written presentation. Students also noted that the CAL lecture was acceptable because they knew that the lecturer had prepared the material but they doubted whether externally produced material would be much better than simply using standard textbooks. (This was interesting in view of the considerable comment in the literature on strategies to overcome the 'not invented here' syndrome and an implicit assumption that the main reason for this lay with the attitude of lecturing staff to material which had been prepared externally). Surprisingly there was no comment on the fact that the material could perhaps have been as effectively delivered in print format. Student response to this suggestion was that the fact that they felt that because the material had been scheduled for use in class they were more motivated to attend and use the material. The group of five students who had been observed to use the system collaboratively also brought up the issue that having equal access to the same material and being able to quickly identify a common theme or issue in the CAL material was useful for encouraging discussion and explanation with colleagues. However, it should be noted that this was not something which was generally felt to be a good point. A number of students (6) were firmly of the opinion that they preferred to study the material independently and did not want to engage in discussion. A variety of reasons were given for this but significant amongst these was the idea that everyone should be responsible for their own learning and that it was not the student's 'job' to help support colleagues. This was an interesting view and one which is particularly significant for those engaged in developing collaborative learning environments. Three students were very vocal in voicing their opinion that using the computer was not useful and one suggested that this was simply adding difficulties to what was already a fairly stressful situation.

Most students felt that the best way to make sense of the CAL material was simply to go through it methodically and take brief notes from each screen. (A pattern confirmed by logs of use). Students felt that there was potential for using the system in a more flexible manner but that, at their stage of not knowing the subject at all, it felt much safer to assume that the structure implied by the layout of the 'overhead' was the best way of using the different sections. Only four students felt that they were confident about dealing with different points in a non-sequential manner. Six students commented that it was useful to be able to get a quick overview of the whole lecture before starting to study parts in more detail.

The discussion from the feedback session therefore showed a considerable diversity of opinion in terms of usefulness of CAL lectures and strategies for using the system.

10.3.1.4 Monitoring Student Use through automatic tracking

As noted above an automatic tracking mechanism was implemented subsequent to the formative evaluation of usability of the prototype. The tracking mechanism was implemented using OpenScript coding (Asymetrix Toolbook's scripting language). The tracking mechanism was designed to provide a disk record of the name of each page visited and also recorded each instance in which a student activated a 'hot word' which linked to a graphic or additional explanatory text or reference. The system also recorded the time at which the student opened a particular page or window of linked information. Thus for each student a disk based tracking log was built up which provided an accurate summary of the manner in which the student had progressed through the courseware. An example of a tracking log is provided in Appendix 9.

In the lecture based material used at this stage in the formative evaluation there were a total of 43 pages. From the opening screen the user could select one of six options to provide access for topics to study. (Options 5 and 6 were further subdivided into 3 sub options). Each option and suboption took the user to a sequential sequence of pages containing more detailed information on the topic chosen. A screenshot of the opening page of the lecture illustrating these options is provided in Figure 10.4 below. Tracking logs were recorded for 27 postgraduate students who had used the courseware.

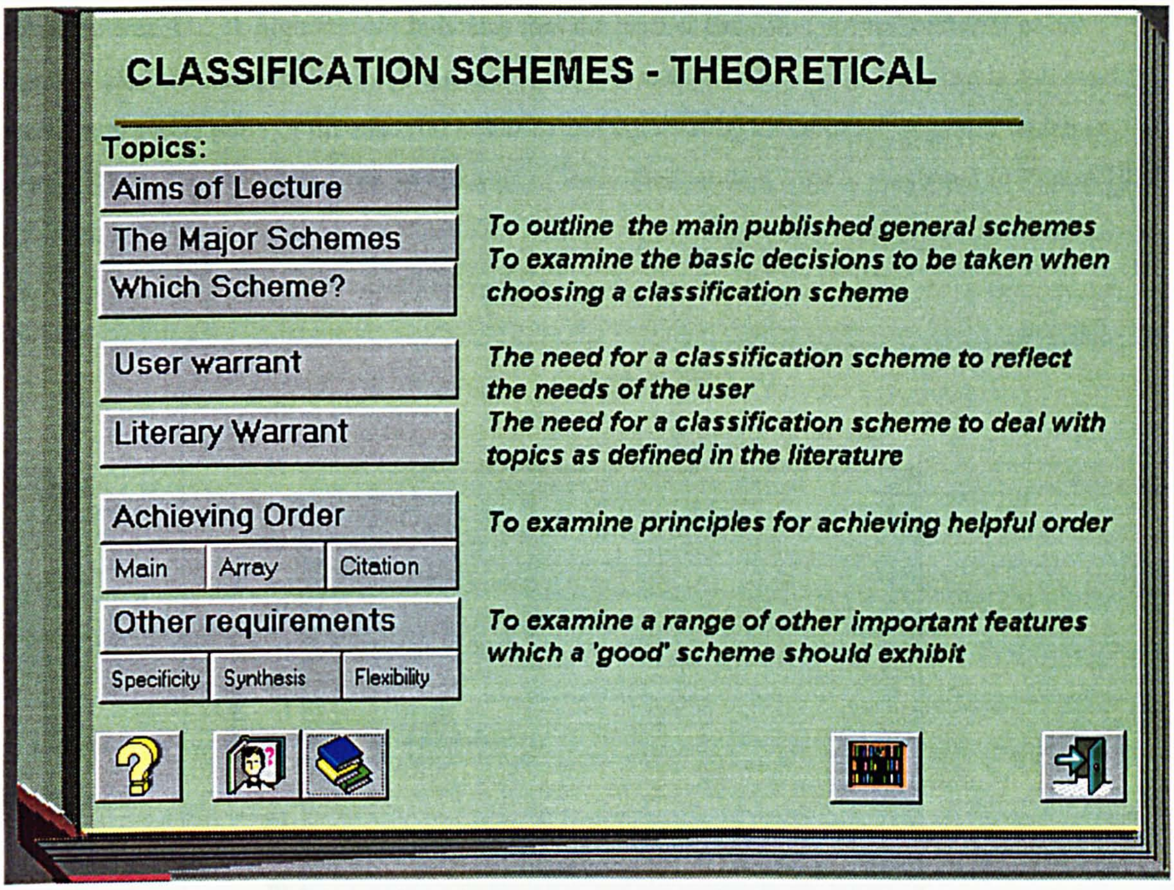

Figure 10.4 - Opening Screen for Topic – Classification Requirements showing menu of options

A completely linear approach to using the package would be indicated by:

- Selecting each topic in the order implied by its position on the opening screen.
- Within each topic examining each page sequentially and activating further explanations or examples on the screens on which they occurred

In this case a score for linear processing of information could be derived fairly easily in accordance with a methodology devised by Ross to study interactivity. (Ross, 1999). To analyse interaction a simple scoring system was adopted which involved recording +1 each time a student followed the expected linear route and recording -1 when the student backtracked to previous screens or visited topics in a non progressive and non sequential order. In addition activation of hotwords contributed a further +1 to the navigation 'score'. The navigation scores were then compared in terms of how closely they clustered around the ideal linear score which in this case was 43. A higher score indicates that the learner has often re-read material or has quickly scanned material before going back over it systematically. A lower score is achieved if the learner omits parts of the material either by not completing all screens. A graph which is derived from figures taken from an analysis of individual student logs is presented in Figure 10.5 (below).

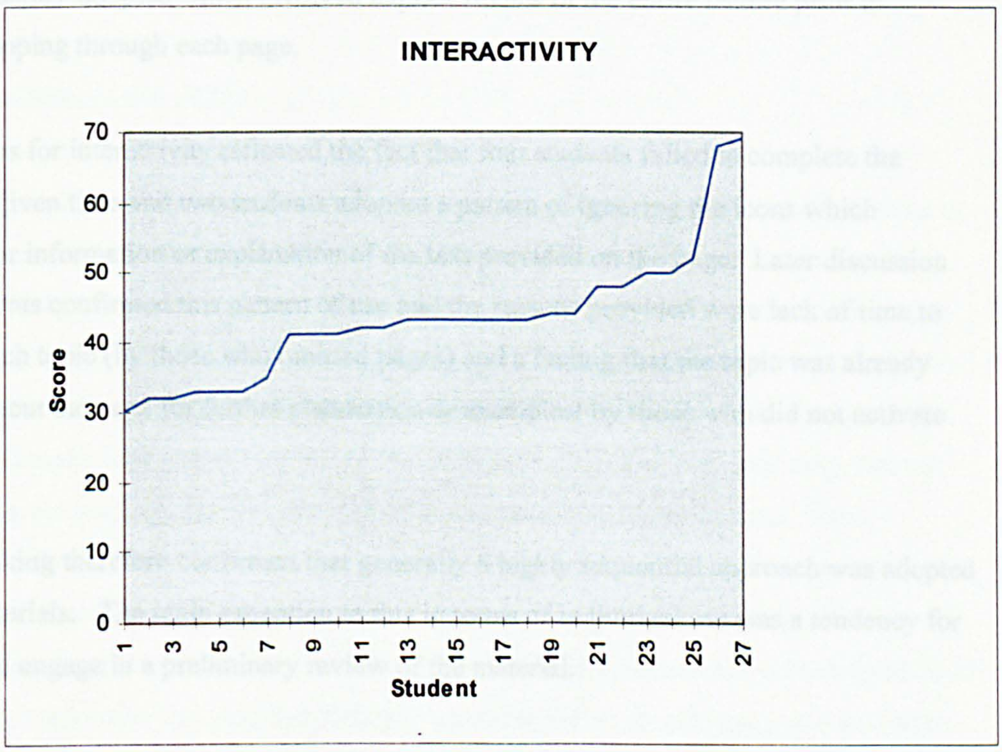

Figure 10.5 Interactivity measured by sequential progression through courseware pages

An element of tolerance had to be built into analysis of logs to derive figures for individual interaction (to allow for student error or small variations in normal pattern of use). By randomly sampling some of the logs it was found that this variation was within a range of +2 or – 2. Thus examining the graph (Figure 10.5) it was reasonable to establish cut off points at 40 and 46 for the purpose of categorising students as exhibiting either a high level of interaction (score greater than 46), linear tendency (40-46) and failure to cover all material (score less than 40).

The benefit of taking an approach to formative evaluation which uses a range of different instruments to measure student interaction became obvious when examining the logs derived from automatic tracking. The higher level of interactivity was associated with students who had been identified as working collaboratively and was a consequence of a great deal of flipping back and forth of 'pages' in order to discuss points and compare information with material which had already been studied. In addition two students' scores reflected a very high level of interactivity because of strategies adopted which involved a quick review of the entire lecture prior to sequentially stepping through each page.

The lower scores for interactivity reflected the fact that four students failed to complete the material in the given time and two students adopted a pattern of ignoring the icons which presented further information or explanation of the text provided on the page. Later discussion with these students confirmed this pattern of use and the reasons provided were lack of time to fully explore each topic (by those who omitted pages) and a feeling that the topic was already understood without the need for further elaboration or examples(by those who did not activate links).

Analysis of tracking therefore confirmed that generally a highly sequential approach was adopted to using the materials. The main exception to this in terms of individual use was a tendency for some students to engage in a preliminary review of the material.

10.3.1.5 Direct Feedback during tutorial sessions

As noted in the section 10.2.7, a feature was also implemented which allowed students to feed comments directly to the lecturer. Only two comments were received from students who used the online feedback but these were considered very significant. The comments were made by two students who were anxious to emphasize that they felt that the use of the CAL materials to deliver the lecture should not be compulsory and one further commented on having serious difficulty in using computers and feeling disadvantaged during the session because of this.

10.3.2 Formative Evaluation of Practical Materials

Practical classes were supplemented by delivery of material in CAL format. The CAL material provided covered the equivalent of two one hour practical sessions. This was delivered in the laboratory over two weeks, each student attending two laboratory sessions. A maximum of 12 students could be accommodated in the laboratory in one session, thus 6 one hour laboratory sessions were involved (2 sessions for each student). These sessions were additional to the students' normal practical sessions on bibliographic classification and involved additional material for practice and supplementary examples. The basic methodology concerning the application of the techniques discussed in the CAL material had already been provided in traditionally delivered seminars and the material was re-stated in sections of the CAL package.

10.3.2.1 Observation of Use

As with evaluation of the lecture based material the researcher was present during all sessions in the laboratory and used the Anecdotal Record Form to record the behaviour of students when using the courseware. Four students left within the first fifteen minutes of the class claiming to have completed the work and found that much of it repeated what was given in previous practical sessions on the topic. Two students were obviously very unsure of how to proceed and needed considerable guidance on how to use package. It was found in fact that their difficulty was not confined to using the package but also encompassed understanding of the content. Basic principles of classification appeared to have been misunderstood and the students were advised to follow the tutorial package carefully making sure they understood the basic theory before progressing to examining and trying out examples. Two students who had not yet reviewed all of the material were concerned that they had to finish reviewing all of the examples and wished to return to a further session later that day arranged for other students. Three students spent a considerable amount of time copying the entire contents of the text from examples pages into the notes area.

Subsequent to the laboratory sessions in which students had been observed using the CAL package, four students who had been unable to attend the scheduled class requested the material for independent study. These students were provided with the CAL package on disk and asked to complete a questionnaire. However, the questionnaires collected from this type of use of the system were not included in the analysis because the conditions in which they were using the material may not have been typical. Responses received from those who attended the class were made in the context of use of the material as part of a scheduled class rather than as 'safety net' material to compensate for having missed the class.

The main issues arising from observation of use concerned the manner in which students approached use of the CAL materials. The bulk of the students obviously found that the material was useful and spent considerable time examining worked examples and appeared to be very active in making connections between the examples and the explanatory material which dealt with the general principles on which the examples were based. However, when considering how the students used the system there appeared to be three main patterns. These were:

1. students who worked very sequentially and used the system in exactly the same manner as they were used to having material delivered in classes i.e. by exploring the principles first then examining worked examples and finally engaging in practice
2. students who focused very much on studying and taking notes from the examples given;

and

3. students who appeared to be biased towards almost exclusive use of practice (or 'learning by doing') even to the extent that they would employ this strategy in cases where they had not been introduced to a particular technique and had little chance of being able to 'guess' the procedure to apply.

Many students obviously made considerable use of the facility to allow them to try out examples themselves and check their own answers and worked examples. In doing so they were far less reliant on the tutor than in a traditional class setting where they may have to wait for the tutor to find time to see them individually and provide an explanation of why they had not been successful in what they were attempting. Some students obviously had difficulty in adopting different strategies for learning and several seemed to feel it was necessary to cover every page of the tutorial. These issues were discussed in structured feedback sessions held the week after students had completed their exploratory use of the CAL materials.

10.3.2.2 Questionnaire

All students completed a questionnaire which was designed to elicit their attitude to using CAL to supplement practical classes. (Appendix 14). Responses are presented in Tables 10.13 and 10.14. As in the evaluation of the lecture based material, an introductory section of the questionnaire was designed to ensure that there were no major problems presented by use of the interface. The second section of the questionnaire was designed to uncover any problems students had with the general approach and to gain feedback on general attitude towards usefulness of the CAL resource and the manner in which it had been used.

Table 10.13 Questionnaire on Practical Classification Courseware General Question Section

Question Posed	*Responses (n = 28)*						
1. Was it clear to you why you were using the package?	Clear	19	7	2	0	0	Unclear
2. Did you find the package easy to use?	Easy	10	9	2	7	0	Difficult
3. Did you find the information appropriate for your course	Relevant	17	10	1	0	0	Irrelevant
4. Did you find that the information was presented in an interesting manner	Interesting	15	10	2	1	0	Boring
5. Specific Problems Notes	None noted						

The feedback from the questionnaire shows a very high level of satisfaction with the design and usability of the system itself. As this had been thoroughly tested at the development stage problems were not envisaged. None of the students found it extremely difficult to use, however, some obviously did have moderate difficulties. This did not appear to triangulate accurately with the data derived from observations of use where it was noted that at least two students had very severe difficulties and it was decided that this was an issue which should be pursued further in feedback sessions.

Table 10.14 Questions related to study preference and learning

Question	*Responses (n=28)*					
Has the material presented in the package increased your understanding of practical procedures for bibliographic classification?	Yes	20	Partly	5	No	3
Reasons provided for response to Q 1.	Yes: Able to take in the material at my own pace (7 responses) The examples and questions make it really interesting (7 responses) Much more interesting than just watching the lecturer do the examples (3 responses) Able to use the material the way I wanted to (3 responses) No: Why do we have to use computers (3 responses) Subject is made too complicated (4 responses)					
Do you feel you learn more or less easily using the CAL package than during normal practical sessions?	Less	3	Same	6	More	19
How would you rate your overall attitude to learning using CAL packages?	+ve	23	Neutral	2	-ve	3
Would you like to see CAL packages made available for other parts of your course?	Yes	22	Unsure	3	No	3
Give an example or examples of what you liked best about learning while using the CAL package	Ability to go at own pace (13 responses) Able to check answers immediately (7 responses) Makes learning more fun (4 responses) Left blank (4 responses)					
Give an example or examples of what you liked least about learning while using the CAL package	Having to use keep cross checking schedules (12 responses) Condescending approach (2 responses) Need to have simpler examples (2 responses) Computers don't work for me (3 responses) Left blank (9 responses)					
Other Comments	Need more time to use the system (3 responses) Want the rest of the material in this form (6 responses)					

All but three students reported that they felt the system had helped them to learn more about bibliographic classification. The main positive reasons given for this were associated with the ability which this mode gave students to work at their own pace and the control provided using the examples and test items provided. All comments, therefore, could be associated with the increased level of learner autonomy. This was confirmed within the questionnaire when examining the comments students made about what they liked best about using CAL. From those who felt that their learning was not helped by using the CAL material, negative comments which were provided were concerned the issue of having to use the computer to access the material (raised by 3 students) and problems with the subject material itself (4 responses). In the case of the subject material the comments appeared to be contradictory, 2 students indicating that the material was too easy and 2 indicating that it was too difficult.

As a preferential mode of study and in response to being asked whether CAL material should be developed for other parts of the course, only three students' responses indicated that they would prefer not to study using CAL. It should be noted that these were the same students who reported that they did not learn as well when using CAL and all provided responses which indicated a feeling that 'computers don't work for me'.

Most of the negative feedback which was received concerned the issue of having to use bibliographic schedules whilst using the CAL material. However, as noted in the section on the formative evaluation of usability of the package, (Section 10.2.7) this was not a problem that could be avoided easily unless authentic assessment and examples were to be abandoned, as it was not possible to include an online version of the schedules in the CAL package.

Overall the responses from the questionnaire were positive but persistent negative feedback from a small group of students clearly indicated that CAL as an approach to learning was not acceptable to all learners.

10.3.2.3 Structured Feedback and Confidence Logs

As with structured feedback sessions with students who used the courseware designed to replace lectures, the approach to structured feedback for students who had used the practical skills courseware was to provide a short list of questions which were designed to engage students in discussion of the CAL materials and to encourage constructive criticism of the materials provided. The themes which prompted the set of questions arose out of the feedback given in the questionnaire and out of the observation of how students used the materials.

The following three questions formed the basis of structured feedback with the undergraduate class as they were the points which arose prominently from both observation of use and from the questionnaire survey.

- Do you feel that access to CAL materials would help you to study better?
- How do you approach use of the CAL materials and decide which parts to concentrate on?
- Why do you feel CAL is potentially a good/bad thing for teaching this subject?

Again as an introduction to the feedback sessions students were asked to complete confidence logs to elicit how they perceived their own achievement of the learning objectives set for the sessions.

Confidence logs completed by the students demonstrated that with very minor exceptions students felt that they had achieved the objectives for the practical sessions (Table 10.15) and this was confirmed by questioning during the feedback session.

Table 10.15 Confidence Logs for Practical Based CAL material

Learning Objective	*Number of students confident of achieving the stated objective (n = 28)*
Knowing when to apply standard subdivisions	26
Application of appropriate number of zeroes to introduce standard subdivisions	23
Use of standard subdivisions to classify form	27
Use of standard subdivisions to introduce historical treatment	22
Use of standard subdivisions to introduce geographic treatment	24
Classification of works dealing with history of a country	24
Classification of works dealing with history of a locality	23

Comments arising from structured feedback

With the exception of three students the cohort felt that access to the CAL courseware helped them to study better. Opinions expressed by the students indicated that they felt more in control over what they studied and it was generally agreed that if the material was available freely they would make use of it. A slight dissension to this view was voiced by six students who expressed the opinion that if they were not specifically directed to use the material and given a laboratory slot in which to do so, then they probably would not feel motivated to make the time themselves. Again this accords with comments in the literature that implementation strategy is very important and even when provided as a supplement to a course of study it is advisable to ensure that students are prompted to use the material and that it should be carefully integrated into the curriculum.

The students confirmed the observation by the lecturer (and later by an analysis of log files) that they used a variety of approaches to study using the material. There was evidence that certain students adopted a typically 'serialist' approach to their studies and were largely concerned with the fact that at times the non-linear organisation of the courseware meant that they may have missed something. Other students were very happy with the fact that they could choose themselves which approach they should adopt

Apart from three students who were obviously very unhappy about the use of computers in teaching all students voiced the opinion that the development of courseware for independent use on the computer was useful and that they would like to see the approach extended to cover more topics within the bibliographic classification module. Questioning students on what they found was the most helpful feature of the courseware served to clarify the seeming discrepancy between the observation some students were obviously finding difficulty in using the courseware and the fact that no-one reported serious problems. Four students (previously identified in observation as those having most difficulty) agreed that the most important help was given by the support provided by the lecturer present to help them out when they 'got stuck'. Again this illustrates the importance in an evaluation of ensuring that the circumstances under which the evaluation is conducted are carefully described in order to fully explain the outcome of the evaluation.

10.3.2.4 Automatic tracking of use of CAL courseware

The tracking mechanism which was implemented monitored each page which a student visited. In the practical based material there were a total of 73 pages. From the opening screen the user could select one of six options which determined the practical technique to be studied. From the screen selected the user could then elect to either gain more information on:

1. gain more information on principles on using the technique (3 additional screens for each topic)
2. examine examples (3 additional screens for each topic)

or

3. try out examples (5 additional screens for each topic).

The navigation pattern of students was quite complex and varied. The complexity was reduced to a set of four categories as outlined in Table 10.16.

Table 10.16 Navigation Patterns in Practical Classification Courseware

Navigation Pattern	Number of students (n = 29)
Sequential	18
Sequential with non completion	4
Sequential with 'skipped sections'	2
Random	5

A completely linear approach to selecting a topic for study (indicated by a pattern of use which showed a strict linear sequence of study of topics 1 to 6) was recorded for 18 students (n = 29). Six students did not in fact complete all of the topics. In four cases this was demonstrated by non completion of either the last or penultimate and last topic (which was interpreted as meaning that the student did not have sufficient time to complete the tutorial) and in two cases topics were omitted (topic two in one case and topic 3 in the other). This was interpreted as indicating a decided choice not to examine the topics. In addition five student logs demonstrated a pattern of activity which indicated a highly randomised approach to the study of individual topics but nonetheless also demonstrated complete coverage of the tutorial package.

Having determined which topic to study, at the outset of each topic students could elect to read the explanatory text, examine worked examples or test themselves by attempting some examples. The frequency with which these strategies were adopted within each of the six sections is shown in Table 10.17

Table 10.17 Options Selected when studying practical courseware materials

Topic	Option selected as first choice to study (n = 29)			
	Explanatory Text (Principles)	Worked Examples	Practice Examples	None chosen
1	12	7	10	0
2	15	6	7	1
3	18	5	5	1
4	22	2	3	2
5	18	4	3	4
6	19	3	3	4

The table shows that most students adopted a strategy of reading the explanatory text before examining worked examples or attempting to test themselves. The pattern differed from topic to topic indicating that students thought carefully about which strategy to adopt depending on their degree of confidence in the topic. There was a slight bias towards using the explanatory text as a first option, particularly when dealing with more complex material. Two students demonstrated a preference for attempting to use the worked examples consistently as a first option to studying the topic and a further two students adopted the strategy of always attempting the exercise before either reading the explanatory text or examining worked examples.

Finally, each topic contained 3 screens of explanatory text, 3 worked examples and 5 examples for independent practice. All students who made use of a particular topic consulted every page on which explanatory text concerning basic principles was provided. However, as explained to students in an introductory session, it was not strictly necessary for all examples to be examined or all practice examples attempted. Table 10.18 demonstrates the extent to which students made use of these parts of the CAL materials.

Table 10.18 Pattern of use of sections of tutorial materials

Topic	Pattern of use of tutorial material							
	Number of students using examples or practicing examples (n = 29)							
	Worked Examples			Practice Examples				
	1	2	3	1	2	3	4	5
1	29	22	3	29	29	26	18	17
2	28	20	12	28	20	20	12	12
3	28	18	10	28	25	19	15	12
4	27	25	15	27	18	17	12	4
5	22	12	12	22	13	10	4	4
6	21	13	7	21	15	9	7	5

All students who studied particular topics attempted to complete at least one example and a number of students attempted to view or complete all examples for every topic. Patterns of use varied according to perceived difficulty of the level of topic being studied. A sharper decline in the number of examples being attempted for later topics (in particular topics 5 and 6) was attributed to students feeling under pressure because of lack of time to complete the material. (This was confirmed by students in subsequent discussion)

10.3.2.5 Direct feedback during tutorial sessions

Four students made use of this facility (a button which the student could activate and use to complete a comment to the researcher whilst using the courseware). These comments were not specifically related to the CAL material. Two students used the facility to request individual tutorials because they were finding the entire module difficult and wanted additional help. Two students used the facility to request personal tutorials to discuss problems, in one case because of changed family circumstances and in the second case because of financial problems. This is a useful reminder that all of the interactions which are involved in a 'teaching session' are not necessarily confined to delivering subject content and are often seen by students as an opportunity to make contact with the lecturer to discuss other matters.

10.3.2.6 General points arising from formative evaluation of CAL based practical materials.

Overall the formative evaluation of the practical materials demonstrated that students had a positive attitude to the supplementary teaching material. They clearly saw the value of being able to practise independently and generally had no problems with using the courseware. There was a slight questionmark over the use of computers to learn which was voiced by a small minority of students and was associated with a reluctance on the part of the students to engage with technology in any form.

The courseware allowed students to explore practical aspects of classification using the particular learning strategy with which they felt most comfortable and this, taken in conjunction with the ability to work at their own pace, was seen by students as being a very positive advantage of using the courseware.

10.4 Conclusions

The formative evaluation provided a great deal of useful information about how students approached learning using the CAL materials. Individuals obviously varied in the manner in which they used the system and in part it appeared that this was attributable to the degree of motivation of the students (at undergraduate level), the degree of confidence and comfort when using computers (both at undergraduate and postgraduate level) and the general approach or strategy adopted to the learning task. There was clear evidence that whilst the materials developed were acceptable in terms of perceived usefulness there were reservations about a scenario in which the use of CAL would replace traditional delivery. Whether or not such concerns would affect the performance of students when using the materials in an authentic setting was to be investigated during the summative evaluation of the materials. However, evidence from confidence logs and other evidence gathered from structured feedback with students did not appear to indicate that the learning derived from the use of CAL materials was intrinsically inferior to use of traditional teaching methods for developing the basic theories of bibliographic classification. A more positive response was evident (as would have been expected) to the use of CAL to supplement or provide an alternative to traditional form of delivery in the undergraduate programme.

References:

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Chapter Eleven

Summative Evaluation

The criterion which we use to test the genuineness of apparent statements of fact is the criterion of verifiability. We say that a given sentence is factually significant to any given person, if and only if, he knows how to verify the proposition which it purports to express – that is, if he knows what observations would lead him, under certain conditions, to accept the proposition as being true, or reject it as being false.

(Ayer A.J., Language, Truth and Logic)

11.0 Objectives

- To develop hypotheses concerning student learning when using the courseware developed as part of this research and to evaluate the results of the experiments undertaken to test these hypotheses
- To delineate the descriptive data collected from independent and dependent variables used in statistical tests to determine the validity of the hypotheses which were posed concerning student learning using the CAL courseware developed as part of this research
- To analyse the significance of the findings of the experiments conducted and relate these to the discussion already provided on the literature concerning the evaluation of student learning using CAL

The overall approach adopted in this chapter is to conduct tests and undertake statistical analysis of the results to provide a summative evaluation of CAL courseware. Specifically the experiments conducted relate to the CAL courseware which has been developed and formatively evaluated as described in the previous Chapters Nine and Ten.

By completion of the formative evaluation the suitability and robustness of the system content and interface had been thoroughly tested. As noted in Chapter Nine, and described in the framework for evaluation, the third phase of the empirical testing involved a study of the outcomes achieved when students used the courseware in order to determine the impact of use on achievement levels and, in the case of tests using the lecture based materials, investigations to determine differences in outcome which could be attributed to individual learner differences. This was done through a correlation of performance using the CAL system with two main factors which the phenomenographic study at the stage of formative evaluation suggested were likely to be important variables. These were degree of comfort/confidence using technology and individual learning style. A summary of tests undertaken is provided in Table 11.1.

Table 11.1 Summary of Summative Evaluation of CLASSICAL

Date	*Student Group*	*Numbers*	*Activity*
September 1998 and September 1999	Postgraduate students	67	Administration of computer experience questionnaire Administration of Questionnaire relating to attitude and motivation to study (followed by interviews with a sample of 12 students) System familiarisation
September 1998	Postgraduate students	58	'Traditional' lecture on topic followed by test (34 students) Use of CAL courseware followed by test (24 students)
September 1998 and September 1999	Postgraduate students	67	Lecture 'delivered' using the courseware only
October 1998 and October 1999	Postgraduate students	67	Administration of Learning Styles Test
January – March 1998	Undergraduate students	20	Analysis of use of practical CAL materials and correlation with performance in final practical classification exercise which formed part of the final assessment for module

11.1 The Research Questions and Hypotheses

It was noted as part of the evaluation framework that an important stage prior to summative evaluation was to frame the research questions which would form the basis for the analysis of the evaluation. It was further noted that the research should ensure that at this stage of CAL evaluation the researcher should not attempt to make inferences or draw conclusions other than those which were derived as a direct result of testing the hypotheses associated with the research questions.

Research Questions

In order to evaluate the use of CAL it is suggested in the framework for evaluation that different types of questions must be asked depending on whether the objective of the CAL materials was to replace teaching of a topic or to supplement teaching of a topic. Four research questions were formulated. The first three of questions were based around an objective of replacement of lectures using the CAL material developed for this purpose. The fourth research questions was based around the use of the practical packages developed in CAL format used as a supplement to material delivered during 'conventional' practical workshops.

Thus the summative evaluation of the CAL materials was undertaken in order to address the following research questions:

1. Does the use of CAL based materials as a replacement to providing 'traditional' lectures significantly affect the performance (learning outcomes) of students as measured by a post test of knowledge and understanding of the lecture material?

2. Do learning outcomes differ significantly based on student learning style (as measured by the Gregorc Learning Style Delineator)?

3. Do learning outcomes differ significantly based on student attitude to use of computers (as measured by the Attitude to Learning with Computers Questionnaire)?

4. Does the use of CAL material as a supplement to practical based workshops improve the performance of students as measured by a post test of their ability to perform practical bibliographic classification?

Hypotheses

The hypotheses generated from these questions were that:

1. There is no significant difference in performance between using CAL based lecture materials and attending 'traditional' lectures

2. There is no significant difference in performance when using CAL based materials between students with different learning styles

3. There is no significant difference in performance when using CAL based materials between students with different attitudes to using computers

4. There is a significant difference in practical performance in bibliographic classification which can be attributed to use of CAL based materials as a supplement to practical workshops

Because the context and subjects for testing the fourth hypothesis are entirely different from those of the first three the studies and results are reported below in two sections. The first deals with the first three questions which involved tests using postgraduate students who made use of the lecture based CAL material, and the second deals with the fourth research question which involved an extended test using undergraduate students who made independent use of the skills based CAL materials.

The subjects and experiments used to test these hypotheses are described below.

11.2 Experiments using courseware designed to replace lectures

11.2.1 Context and implementation of the study

The discussion on evaluation developed in the first part of this thesis emphasises the need to be very careful when introducing CAL materials to ensure that the context in which the material is used is carefully recorded and controlled. Any issues which relate to context in which the use of CAL courseware was used should be noted and in particular any factors which are likely to have had an impact on the use of the courseware must be taken into account in the results of the evaluation. Several authors have commented on the importance of implementation as an influential factor which can dramatically affect the outcome of planned trials using multimedia (Reeves, 1997; Draper, 1994; Milne and Heath, 1997). This was confirmed during the formative evaluation stage when a poor experience of using the software caused by computer problems dramatically affected two students' responses and generated a very hostile attitude towards use of computers to deliver teaching materials. The context in which the multimedia CAL packages were summatively tested were thus carefully scheduled and this was particularly important because this stage of the research coincided with a move to a new building which was accompanied by severe network disruption. Fortunately, because the CAL system was designed to run on stand-alone machines this did not have an impact on the study. However, it may have had an impact on student attitude towards use of computers. Thus it was even more important to ensure a smooth implementation and thoroughly check all workstations to ensure that the software was functioning correctly.

In other respects the logistics of introducing the packages to students was very carefully considered and took the form of:

- a comprehensive briefing for students on the use of the CAL materials
- review of any pre-requisite knowledge which was required in order to undertake the particular lesson being studied using the CAL software (thus two postgraduate students who had not attended the introductory sessions on classification were provided with that material prior to using the CAL lesson)
- ensuring that students had ample opportunity to discuss any difficulties they felt they might have prior to use of the CAL material

- ensuring that the students understood the significance of the material to be delivered as an integral part of their course and that it was important for the assessment which they would have to prepare in order to pass the end of unit assessment

In order to ensure that there was no instructional bias it was arranged that a laboratory technician attended the supervised CAL sessions for postgraduate students and was on hand throughout the sessions in order to deal with any technical problems. (None were in fact reported)

11.2.2 Subjects

The first three research questions were tested using postgraduate students as subjects and made use of the CAL materials which were developed with the intended aim of providing an alternative delivery mechanism to using 'traditional' face to face lecturing. In order to have a sufficient number of subjects to provide a statistically accurate sample,[1] postgraduate students in cohorts 1998/9 and 1999/2000 were used as test subjects (59 from 1998/9 and 8 from 1999/2000). It should be emphasised that all data collection and tests on subjects were performed in exactly the same manner for both cohorts. The investigation required the collection of a large volume of descriptive data about the subjects in order to ensure that observed effects were the result of the variables being tested. This was done using a combination of questionnaires and interviews. Specific learner characteristics are dealt with in the following section on descriptive statistics.

11.2.3 Student characteristics

This section delineates descriptive data which were collected as part of the tests to examine the research questions.

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1 This was particularly important in the test involving learning style where the sample from the 1998/9 cohort provided an uneven number of students over the four style quadrants. Gregorc warns that in order to achieve meaningful comparative results in learning styles experiments there should be relatively even number of subjects represented in each of the four learning style quadrants. Thus results from eight of the students who took part in the experiments in 1999-2000 were included in the study.

From the literature within the context of the research conducted here, the following factors were all considered to be potentially important in determining the outcome of an 'educational intervention' particularly with respect to a CAL courseware:

- Motivation
- Prior Domain Knowledge
- Degree of confidence with using computers
- Learning Style

Although from the analysis of the literature on the use of CAL they were considered to be potentially significant, the current research did not set out specifically to investigate the influence of gender and age. However demographic data was gathered on gender and age and cross tabulations performed to ensure there was no bias between these characteristics and learning styles or degree of computer confidence (the independent variables being studied). This was important to confirm that these were not variables that were closely correlated with other factors and hence may have been hidden causal factors in an analysis of the results.

11.2.3.1 Motivation

The subjects being tested were all registered on the Postgraduate course in Information and Library Studies. As course leader for this cohort of students the researcher is normally involved to a great extent in the induction week for these students and this afforded the opportunity to issue a number of questionnaires to assess a variety of background attributes. An advantage of this approach was that students did not associate the tests specifically with the experiments on use of CAL in which they would subsequently be engaged and simply viewed the collection of data as part of a routine process of admission and induction.

The instrument used to check student motivation was part of a larger questionnaire – the Student Personal and Study Profile (Appendix 15). As part of the questionnaire students were asked to rate their motivation to perform well on the course by using a Lickert scale (range 1 to 5 reflecting low to high). They were further asked to comment on what they felt motivated them to do well. It was expected (based on past experience in teaching postgraduate students) that the overwhelming response would be related to job prospects. A further question was therefore included in the questionnaire to elicit student views on how important achievement of a good result in their academic studies was an influencing factor on job prospects.

Motivation is an extremely difficult variable to accurately measure and in order to confirm the reliability of the questionnaire as an instrument to measure motivation, a series of follow up interviews with a randomly selected group of twelve students was arranged in order to confirm that the questionnaire provided an accurate assessment of student attitude. In addition, as course leader, the researcher was obviously very aware of any problems which affected the cohort generally or of specific problems being encountered by individual students. The interviews were intentionally informal in order to ensure that students did not feel that they were subjects of an experiment - a factor which may have influenced their responses.

Analysis of questionnaire and interviews

Analysis of the questionnaires and interviews showed that the motivation level was extremely high (as would have been expected on a vocational postgraduate course. Sixty-five subjects (n = 68) rated their motivation using the highest scores (5 or 4) and of the remaining three subjects gave a rating of 2 (average) on the Lickert scale. Only 1 student rated his motivation as low and in fact withdrew from the course within a week and hence was not included in the study. In addition 64 students (94%) responded that the most significant factor in motivating them to do well was related to job prospects and the same students also rated academic performance as a highly significant factor in gaining suitable employment (selecting rating five on the appropriate Lickert scale).

Subsequent interviews confirmed the picture of a highly motivated cohort. In six cases (50%) students expressed the view that they felt that this was an opportunity to learn from their experience in their undergraduate degree and felt that more concentrated application to their studies would give them the opportunity to demonstrate, if only to themselves, that they could do better academically than was evident in their performance at undergraduate level (measured in terms of the class of degree which they were awarded at undergraduate level).[2]

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[2] It should also be noted that as personal tutor and course leader to the postgraduate cohort the researcher was able to monitor the motivation of the students and this was done by further interviews and meetings with the cohort throughout the first semester of their study.

Motiviation being extremely high, it was thus not considered to be an important influential factor in the interpretation of the statistical results in the tests described below.

11.2.3.2 Prior Domain Knowledge

The level of prior domain knowledge was not expected to be high. This was confirmed by using a very simple questionnaire which was issued at the start of the module on bibliographic classification after the lecturer had introduced in outline the content of the module. (Appendix 16). Student responses uniformly indicated that no student had any prior knowledge of the theory of bibliographic classification and none had working knowledge of using classification in libraries.

Prior domain knowledge was thus not considered to be an influential factor in the interpretation of the statistical tests below. Of course, there may have been a variation in generic and transferable skills of the cohort being tested. The most significant of these skills in relation to the current research is the level of familiarity with computers and this was assessed separately as a potentially significant variable.

11.2.3.3 Computer Confidence Level

Research discussed in Chapter Five indicated that attitudes and views towards CAL are influenced by user attitudes to the computer. This study focused on learning from the computer; thus, it was essential that a measure be included which ascertained computer confidence level.

A basic knowledge of how to use computers was necessary for the purposes of this study but a high level of competence was not required. It was quickly established that all of the students possessed the basic minimum required knowledge. From the start of the academic year 1995/6 all postgraduate students have routinely completed a Prior Computer Experience Questionnaire during the induction week at the start of their course. (See Appendix 17). This confirmed that whilst there was variation, within the experimental cohort, in level of prior experience all students had a basic familiarity with use of computers. As a component of their taught course students were provided with a basic induction on computers and information technology using the

University network. This included the basics of using the appropriate operating system and applications software prior to being tested. It was thus ensured that students had received some training in the very basic skills required to use the computer to load and use the CAL package.

The purpose for which the questionnaire was designed was to determine students' own perception of their level of IT awareness and experience and this information was used to ensure that learners' were allocated to an appropriate 'stream' for IT applications training. In addition for the cohort being studied a supplementary questionnaire was administered which included a number of questions which specifically addressed the issue of student attitude to use of computers. (Appendix 18). This was considered essential in order to give a more accurate differentiation based not only on students' prior experience but also on their degree of confidence or 'comfort' in applying such skills.

The results from an analysis of these questionnaires were used to determine the allocation of students to appropriate groups for the purpose of this study. Both questionnaires were unique and therefore it is not possible to quote published statistics on reliability of the instrument. However, the questions posed were derived largely from an analysis of similar instruments (including the TILT group Prior Computer Experience Questionnaire and the Computer Attitude Questionnaire) and these have been used successfully in previous studies. A member of the lecturing staff (not the researcher) reviewed the questionnaires and allocated the students to one of four categories (novice, familiar, experienced and expert) for laboratory and tutorial activities in this subject area. Group size was on the whole comparable with a bias toward the category 'familiar'. This is explained because the allocation was based on a comparative evaluation of responses rather than being determined by strictly pre-defined scores to determine group membership. Of the 67 students who took part in the experiment group composition was as shown below (Table 11.2) and illustrated graphically (Figure 11.1).

Table 11.2 Computer confidence questionnaire

Category of computer confidence	*Number of students (n=67)*
Novice	16
Familiar	24
Experienced	13
Expert	14

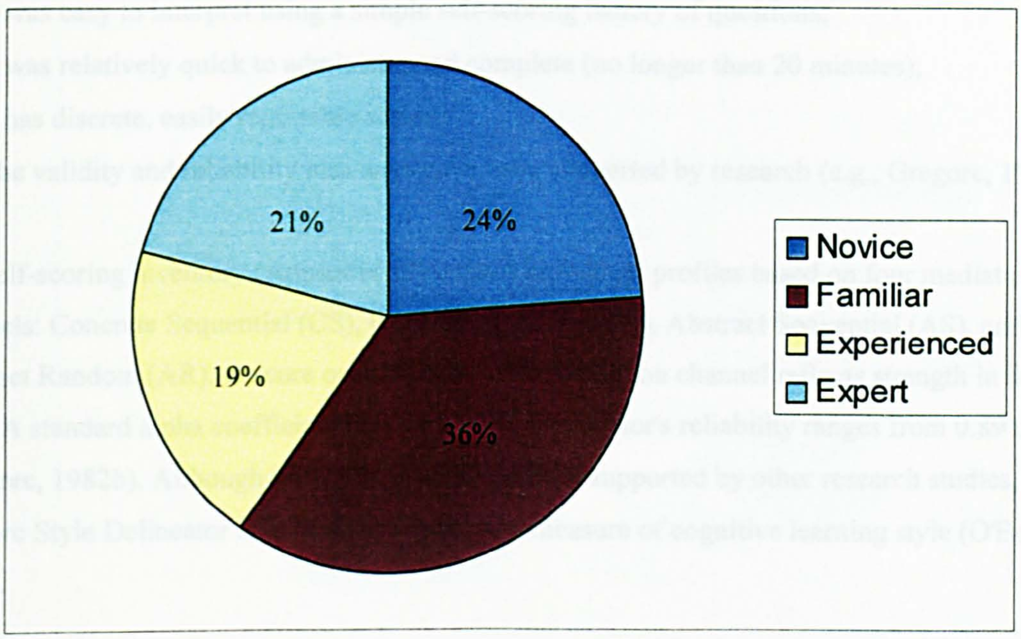

Figure 11.1 Subjects' Computer Confidence Level

11.2.3.4 Dominant Learning Style

An important aim of the research was to establish the influence of learning style on use of CAL. The learning style instrument selected was the Gregorc Learning Style Delineator. The instrument is discussed extensively in Chapters 5. A review of learning style inventories was undertaken prior to selection of the Gregorc Learning Style Delineator. Apart from the Gregorc Learning Style Delineator the other instruments which were examined were Kolb's Learning Style Inventory, the Myers-Briggs Inventory , and Soloman's Inventory of Learning Styles . However, on inspection the Kolb inventory was considered to be too laden with jargon and difficult to answer without extensive training. The Myers-Briggs inventory's focus is on personality rather than learning style and this diminished its effectiveness for the purpose of this research. Soloman's inventory consisted of 28 simple questions which were extremely easy to answer but it was not considered appropriate for students at higher education level as the questions were rather too simple and framed specifically for students in primary and secondary education. Thus the Gregorc Style Delineator was selected, in part, for the following reasons:

- It was easy to administer;

- It was easy to interpret using a simple self-scoring battery of questions;
- It was relatively quick to administer and complete (no longer than 20 minutes);
- It has discrete, easily reportable scales;
- The validity and reliability measures have been supported by research (e.g., Gregorc, 1982a).

The self-scoring inventory (Appendix 19) creates individual profiles based on four mediation channels: Concrete Sequential (CS), Concrete Random (CR), Abstract Sequential (AS), and Abstract Random (AR). A score over 27 in any one mediation channel reflects strength in that area. A standard alpha coefficient measuring The Delineator's reliability ranges from 0.89 to 0.93 (Gregorc, 1982b). Although his findings have not been supported by other research studies, the Gregorc Style Delineator is in wide use today as a measure of cognitive learning style (O'Brien, 1992).

For analysis purposes, the subjects' highest scores were used as an indicator of their dominant learning style. (One subject had equally high scores across each of the four mediation groups and in this case that particular student was omitted from a consideration of the results).

In considering only the 59 students in the 1998/1999 postgraduate cohort it was obvious that there was an imbalance in distribution of learners within the different quadrants of Gregorc's Learning Style Delineator. This was compensated for by administering the same tests to students from the next cohort and including from that cohort four students who were characterised as demonstrating a Concrete Random and four students who were categorised as demonstrating an Abstract Sequential style. All other experimental conditions were replicated for these students. The resultant revised distribution still showed a slight imbalance but this was deemed to be acceptable and does not affect the validity of the findings of the test which sought to determine the impact of learning styles on performance when using CAL. The resultant groups are described below in Table 11.3 and shown diagramatically in Figure 11.2.

Table 11.3 Learning Styles (as measured using the Gregorc Learning Style Delineator)

Learning Style	*Number of students (n=67)*
Abstract Random	19
Abstract Sequential	18
Concrete Random	15
Concrete Sequential	15

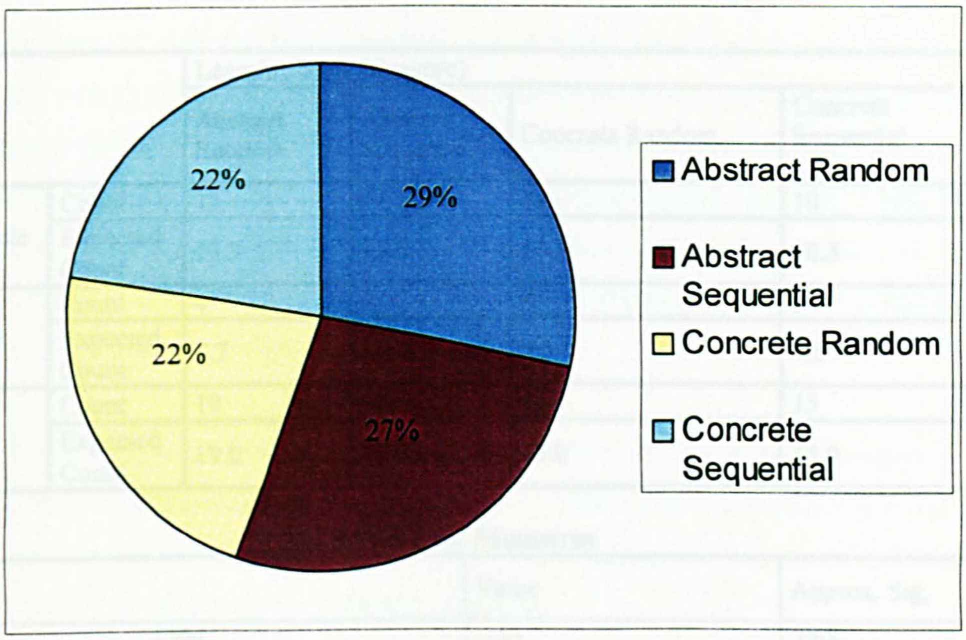

Figure 11.2 Learning Style Distribution

11.2.4 Cross Tabulations with Gender and Age

The majority of participants (47 or 70 %) were female. This is not surprising as traditionally the majority of students undertaking courses leading to a qualification in librarianship are female. As noted in Chapter Five the literature provided mixed views as to whether gender was a significant factor when assessing learning outcomes after use of CAL. The purpose of this study was not specifically to examine the question of gender and performance with CAL. However, in order to ensure that there was no associated bias between gender and learning styles or computer confidence levels (the independent variables being studied) cross tabulation of data was performed using SPSS (Statistical Package for the Social Sciences). In the case of gender and learning style this was particularly important in the view of recent findings reported by Ford et al. which suggest that gender and learning style may be linked (Ford et al., 2001). The results are presented in Table 11.4 (gender and learning style) and 11.5 (gender and computer confidence) and these are respectively graphically shown in Figures 11.3 and 11.4.

Table 11.4 Cross tabulation of Gender and Learning Styles

			Learning Style (Gregorc)				
			Abstract Random	Abstract Sequential	Concrete Random	Concrete Sequential	Total
Gender	Female	Count	15	11	11	10	47
		Expected Count	13.3	12.6	10.5	10.5	47.0
	Male	Count	4	7	4	5	20
		Expected Count	5.7	5.4	4.5	4.5	20.0
Total		Count	19	18	15	15	67
		Expected Count	19.0	18.0	15.0	15.0	67.0

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.153	.668
	Cramer's V	.153	.668
N of Valid Cases		67	
a Not assuming the null hypothesis.			
b Using the asymptotic standard error assuming the null hypothesis.			

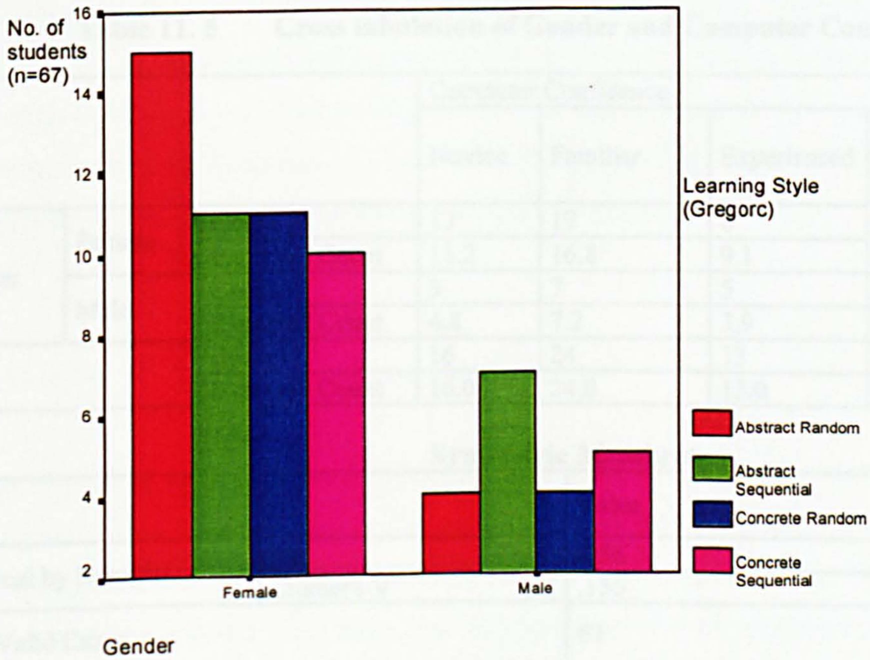

Fig 11.3 Gender correlated with learning style

The expected counts of male and female subjects in each of the four dimensions of learning style was in keeping with the view that gender is not closely associated with learning style. In this case it is interesting to note that males show a slightly higher tendency towards adopting sequential styles than might have been expected had learning style been completely randomly distributed. However, the tendency is not statistically significant and this is confirmed by the fact that both the Phi and Cramer V tests to compare degree of association of nominal data types yield results which are not significant (p=0.668).

The graphical view of the cross tabulation makes the point more clearly than the numeric presentation. Although the results do not support a statistically close association it is important that this is noted and that any evidence that a sequential learning style is correlated with success in use of CAL should cross check the influence of gender.

Gender and Computer Confidence

The cross tabulations presented below are designed to check for a statistically significant correlation between gender and level of computer confidence as reported in the questionnaire surveys described above (11.2.3.3).

Table 11. 5 Cross tabulation of Gender and Computer Confidence Levels

			Computer Confidence				Total
			Novice	Familiar	Experienced	Expert	
Gender	Female	Count	13	17	8	9	47
		Expected Count	11.2	16.8	9.1	9.8	47.0
	Male	Count	3	7	5	5	20
		Expected Count	4.8	7.2	3.9	4.2	20.0
Total		Count	16	24	13	14	67
		Expected Count	16.0	24.0	13.0	14.0	67.0

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.156	.651
	Cramer's V	.156	.651
N of Valid Cases		67	
a Not assuming the null hypothesis.			
b Using the asymptotic standard error assuming the null hypothesis.			

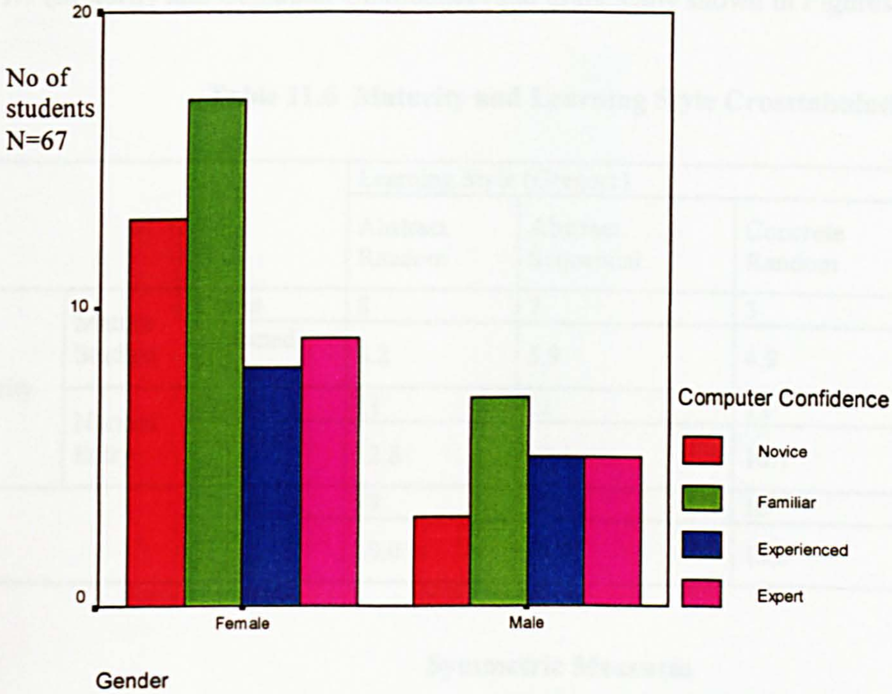

Figure 11.4 Gender correlated with Computer Confidence

The expected counts of male and female subjects in each of the four levels of computer confidence (Table 11.5) was in keeping with the view that gender is not closely associated with computer confidence. This is confirmed by the fact that both the Phi and Cramer V tests (to compare degree of association of nominal data types) yield results which are not significant. The graphic representation of this data also illustrates this point.

11.2.3.4 Maturity of Participants

A substantial number of the participants (22 or 33%) were mature students (defined here as those students who did not register on the postgraduate course within three years of completing their undergraduate degree and had work experience). Again age has been identified in the literature as a significant factor when assessing CAL and again in order to ensure that there was no association between maturity and learning styles or computer confidence levels cross tabulation of data was performed. The results are presented in Table 11.6 (Maturity and Learning Style) and 11.7 (Maturity and Computer Confidence) and graphically shown in Figures 11.5 and 11.6.

Table 11.6 Maturity and Learning Style Crosstabulation

			Learning Style (Gregorc)				Total
			Abstract Random	Abstract Sequential	Concrete Random	Concrete Sequential	
Maturity	Mature Student	Count	8	7	3	4	22
		Expected Count	6.2	5.9	4.9	4.9	22.0
	Normal Entry	Count	11	11	12	11	45
		Expected Count	12.8	12.1	10.1	10.1	45.0
Total		Count	19	18	15	15	67
		Expected Count	19.0	18.0	15.0	15.0	67.0

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.190	.490
	Cramer's V	.190	.490
N of Valid Cases		67	
a Not assuming the null hypothesis.			
b Using the asymptotic standard error assuming the null hypothesis.			

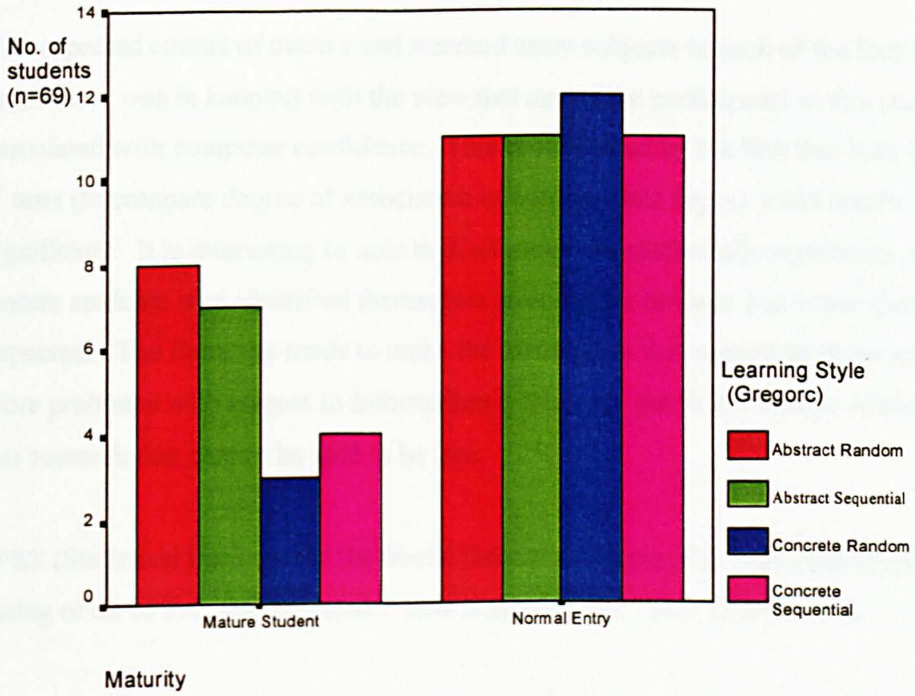

Figure 11.5 Maturity and Learning Styles

The expected counts of mature and standard entry learners in each of the four dimensions of learning style was in keeping with the view that age is not closely associated with learning style. In this case it is interesting to note that mature students show a slightly higher tendency towards adopting abstract styles than would be expected if the distribution was completely random. (Again the graphical view of the comparison presented in Figure 11.6 makes this clearer than the cross tabulation numeric presentation in Figure 11.5). However, overall the results do not support a statistically close association. This is confirmed by the fact that both the Phi and Cramer V tests (to compare degree of association of nominal data types) yield results which are not significant (p= 0.490).

The expected counts of mature and standard entry subjects in each of the four levels of computer confidence was in keeping with the view that age of the participants in this study is not closely associated with computer confidence. This is confirmed by the fact that both the Phi and Cramer V tests (to compare degree of association of nominal data types) yield results which are not significant. It is interesting to note that, although not statistically significant, the number of mature students who identified themselves as complete novices was lower than might have been expected. The literature tends to make the assumption that mature students are likely to have more problems with respect to information technology but in the sample of students studied in this research that cannot be said to be true.

SPSS (Statistical Package for the Social Sciences) Version 9.0 was used to create a descriptive listing of all of the data collected . This is provided in Table 11.8 (below).

Table 11.8 SUMMARY OF DESCRIPTIVE STATISTICS (OUTPUT FROM SPSS)

Gender

		Frequency	Percent	Valid Percent
Valid	Female	47	70.1	70.1
	Male	20	29.9	29.9
	Total	67	100.0	100.0

Maturity

		Frequency	Percent	Valid Percent
Valid	Mature Student	22	32.8	32.8
	Normal Entry	45	67.2	67.2
	Total	67	100.0	100.0

Computer Confidence

		Frequency	Percent	Valid Percent
Valid	Novice	16	23.9	23.9
	Familiar	24	35.8	35.8
	Experienced	13	19.4	19.4
	Expert	14	20.9	20.9
	Total	67	100.0	100.0

Table 11.7 Maturity and Computer Confidence Crosstabulation

			Computer Confidence				Total
			Novice	Familiar	Experienced	Expert	
Maturity	Mature Student	Count	3	8	6	5	22
		Expected Count	5.3	7.9	4.3	4.6	22.0
	Normal Entry	Count	13	16	7	9	45
		Expected Count	10.7	16.1	8.7	9.4	45.0
Total		Count	16	24	13	14	67
		Expected Count	16.0	24.0	13.0	14.0	67.0

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.195	.468
	Cramer's V	.195	.468
N of Valid Cases		67	
a Not assuming the null hypothesis.			
b Using the asymptotic standard error assuming the null hypothesis.			

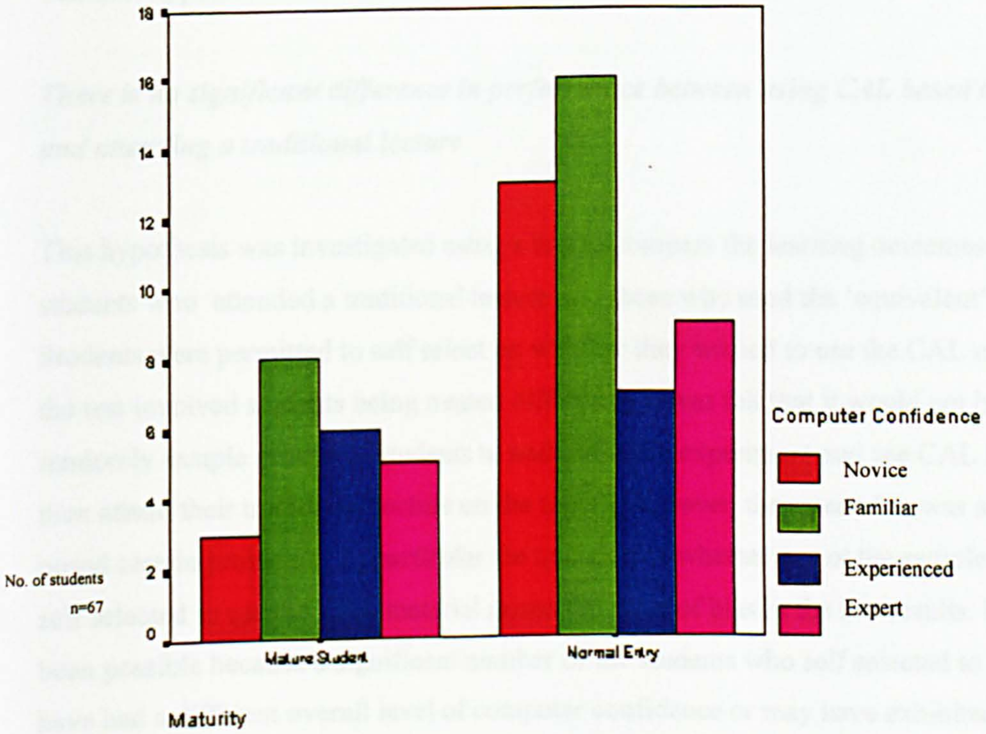

Figure 11.6 Maturity and Computer Confidence

Learning Style (Gregorc)

		Frequency	Percent	Valid Percent
Valid	Abstract Random	19	28.4	28.4
	Abstract Sequential	18	26.9	26.9
	Concrete Random	15	22.4	22.4
	Concrete Sequential	15	22.4	22.4
	Total	67	100.0	100.0

11.2.4 Testing Research Hypotheses 1-3

This part of the chapter uses inferential statistics to explore the descriptive data which has been provided in Section 11.2. thus establishing whether or not the hypotheses posed in Section 11.1 should be accepted or rejected

11.2.4.1 Hypothesis 1

The first hypothesis was that:

There is no significant difference in performance between using CAL based lecture materials and attending a traditional lecture

This hypothesis was investigated using a test to compare the learning outcomes achieved by students who attended a traditional lecture and those who used the 'equivalent' CAL courseware. Students were permitted to self select on whether they wished to use the CAL materials. Since the test involved students being treated differently it was felt that it would not be ethical to randomly sample groups of students to undertake the experiment and use CAL materials rather than attend their traditional lecture on the topic. However, the researcher was aware that this posed certain problems. In particular the question of whether or not the sample of students who self selected to use the CAL material raised the issue of bias in the test results. Bias may have been possible because a significant number of the students who self selected to use the CAL may have had a different overall level of computer confidence or may have exhibited particular learning styles. In addition there was the danger of engendering a 'Hawthorne' effect i.e. students who self selected to undertake study using the CAL system were those students who were eager to show their willingness to engage in the experiment and hence may have performed better because of this additional motivating factor. In order to ensure that such bias was reduced to a minimum post hoc tests were conducted to ensure that there was an even distribution of learning styles and levels of computer comfort in the students who had selected to use the CAL material and the results of this analysis would moderate any findings reported on the basis of the statistics.

Analysis of the composition of the test group using CAL

The distribution of learning style and computer confidence level within the CAL group was analysed using SPSS in order to determine whether there was a significant bias in the composition of the groups based on student learning style or degree of confidence with computers. The results are presented below in Tables 11.9 (mode of study and learning style) and 11.10 (mode of study and computer confidence) and illustrated in Figures 11.7 and 11.8.

Table 11.9 Mode of Study and Learning Style Crosstabulation

			STYLE				Total
			AR	AS	CR	CS	
Mode of Study	CAL	Count	9	6	1	8	24
		Expected Count	7.3	7.3	3.9	5.6	24.0
	Lecture	Count	8	11	8	5	32
		Expected Count	9.7	9.7	5.1	7.4	32.0
Total		Count	17	17	9	13	56
		Expected Count	17.0	17.0	9.0	13.0	56.0

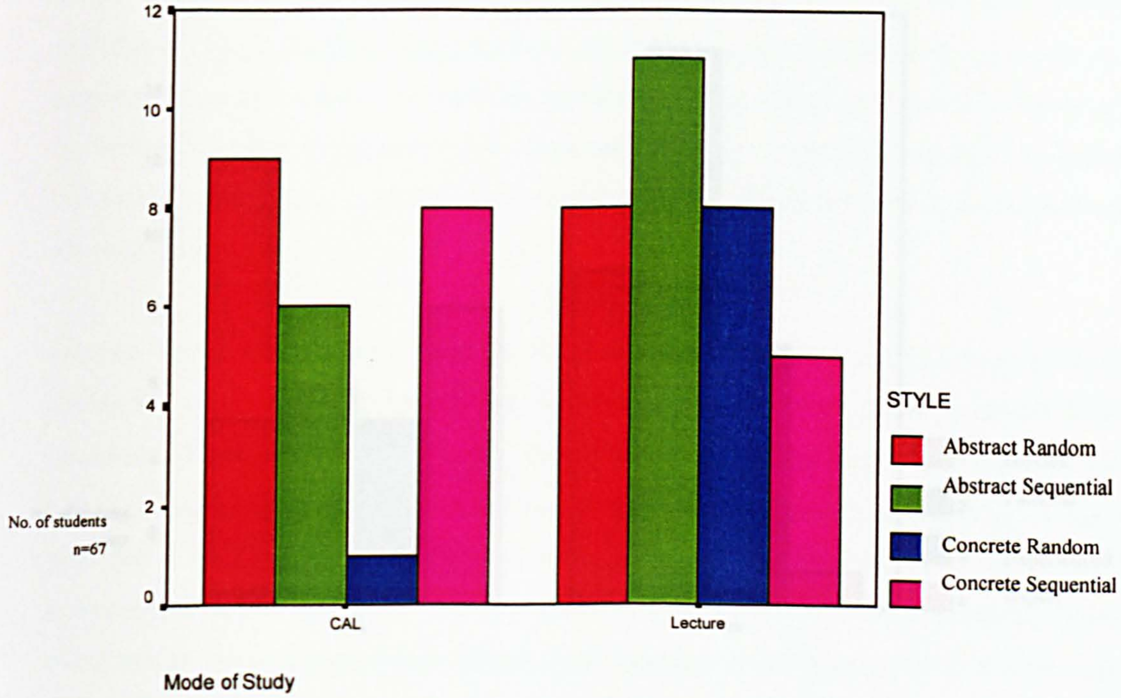

Figure 11.7 Mode of study correlated with learning style

There are some variations in the 'ideal' distribution (i.e. the distribution expected had the students selected mode of study completely randomly) when we compare students who elected to undertake using CAL and those who chose to take part in the lecture. It can be seen from the cross tabulation that these are not statistically significant (given the relatively small size of the sample for the study). However, it is worth noting that the cross tabulations presented demonstrate that in terms of learning style a bias which is evident is that fewer Concrete Random learners favoured using the CAL materials. Interviews with these students established that the main reason for this was their uncertainty about whether or not they would 'miss out' on important facts which may be introduced in the lecture and this may reflect the reported tendency of such learners to be more competitive in their approach to learning (See Chapter 5), but it is difficult to be certain of this.

Table 11.10 Mode of Study and Computer Confidence Crosstabulation

			Computer Confidence				Total
			Novice	Familiar	Experienced	Expert	
Mode of Study	CAL	Count	5	6	5	8	24
		Expected Count	6.0	9.0	5.1	3.9	24.0
	Lecture	Count	9	15	7	1	32
		Expected Count	8.0	12.0	6.9	5.1	32.0
Total		Count	14	21	12	9	56
		Expected Count	14.0	21.0	12.0	9.0	56.0

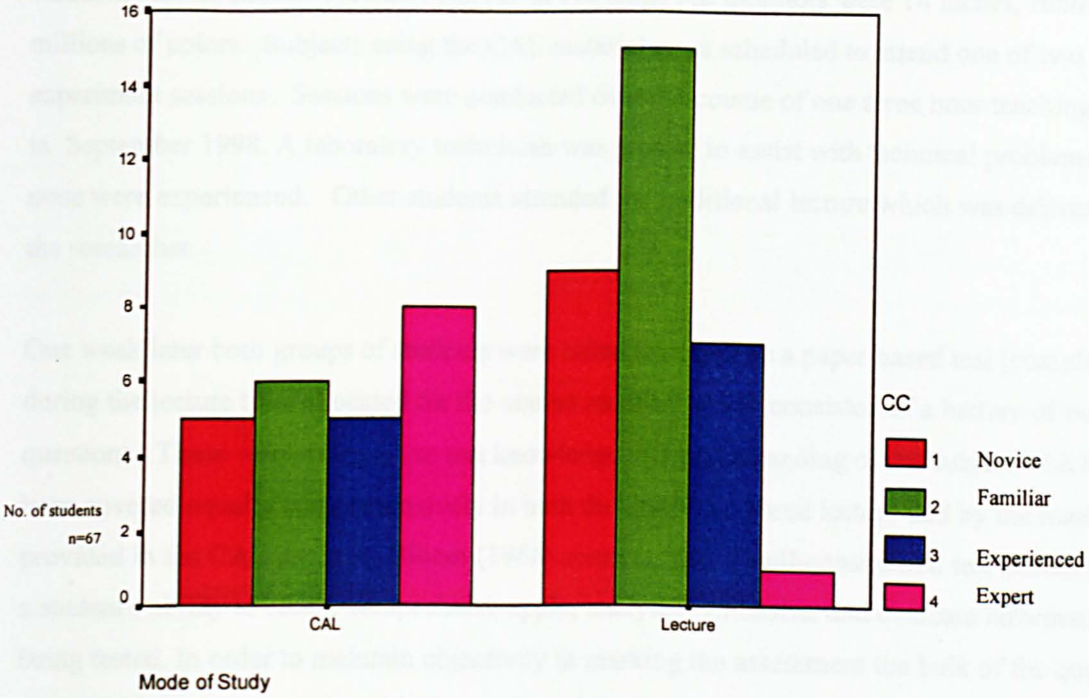

Figure 11.8 Mode of study correlated with computer confidence

In terms of degree of computer confidence the main point worth noting is that the students who exhibited a high level of confidence with computers tended to favour using the CAL material. It would appear, therefore, that irrespective of how they actually performed using the CAL material these students perceived that this mode of study would be beneficial to them.

Thus there were indeed some biases in the self selecting sample. Although, these were not statistically significant, given the small size of the sample it was considered that these merited consideration and should be taken into account when examining the result of the experiment.

Experimental Treatment

24 copies of the courseware 'lecture' were duplicated onto floppy disks and students undertook to complete use of the courseware within a one hour scheduled laboratory session. Each workstation used had Asymetrix Toolbook run time system installed and students could load the programme from floppy disk and use the CAL materials. Notes taken by students were written as a text file onto the floppy disk at the end of the session and students could take a copy of these by making a copy of the file (A:/NOTES.TXT) to their own network directory. The computer laboratory used was equipped with 12 IBM Pentium PCs . Each computer had 64 megabytes of

Random Access Memory (RAM) and ran at 100 Mhz. All monitors were 14 inches, running millions of colors. Subjects using the CAL material were scheduled to attend one of two experiment sessions. Sessions were conducted over the course of one three hour teaching block in September 1998. A laboratory technician was present to assist with technical problems but none were experienced. Other students attended the traditional lecture which was delivered by the researcher.

One week later both groups of students were asked to complete a paper based test (completed during the lecture time allocated for the course module) which consisted of a battery of twenty questions. These were designed to test knowledge and understanding of the subject which had been covered equally comprehensively in both the orally delivered lecture and by the materials provided in the CAL package. Bloom (1964) contends that a well-constructed test should measure a student's ability to recall, comprehend, apply, analyse, synthesise, and evaluate information being tested. In order to maintain objectivity in marking the assessment the bulk of the questions were multiple choice. As noted in the review of the literature such questions are not generally considered to be good instruments to accurately test the level of a student's understanding. However the questions were carefully planned in order to ensure that they were not simple tests of memory but involved understanding and inference of the information which had been provided.(Appendix 20).

Comparative performance of students using CAL and Lecture

An independent t-test was performed which examined the performance of different students in the assessment which was administered one week after the lectures and CAL sessions had been completed. The SPSS output listings of the t-test are presented in Table 11.11 (below).

Table 11.11 Comparative study on level of performance using CAL and not using CAL materials

Group Statistics

	Mode	N	Mean	Std. Deviation	Std. Error Mean
SCORE	Lecture	32	10.3750	2.5113	.4439
	CAL	24	10.5833	2.9623	.6047

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
SCORE	Equal variances assumed	1.046	.311	-.284	54	.777	-.2083	.7325	-1.6769	1.2602
	Equal variances not assumed			-.278	44.816	.783	-.2083	.7501	-1.7194	1.3027

The results of the test demonstrate that there was no significant difference in performance which could be attributed to the mode of study (p = 0.311). Simply examining the mean scores for students to determine their performance shows a slight bias in favour of the CAL materials but as has already been noted this could very easily be explained by the fact that the students who undertook to study using the CAL materials had already displayed a preference to engage in the experiment and may well therefore have been expected to be more motivated to perform well.

Thus the hypothesis that there is no significant difference in performance between using CAL based lecture materials and attending a traditional lecture is affirmed in this case.

11.2.4.2 Research Questions 2 and 3

The following section describes the statistical tests which were undertaken to test the second and third hypotheses posed by the research. These were:

Hypothesis 2

There is no significant difference in performance when using CAL based materials amongst students with different learning styles

Hypothesis 3

There is no significant difference in performance when using CAL based materials amongst students with different attitudes to using computers

Both of these research hypotheses required the investigation of the effect of variance in individual differences on performance in using CAL. The statistical instrument which was used in both tests was the one way ANOVA. Both tests were one treatment experiments.

All students were required to use a CAL lecture as a substitute for a lecture being delivered in the 'traditional' manner. Students were scheduled to take part in the experiment in groups of 12 (in order to accommodate students in the laboratory being used for the experiment). A laboratory technician was present to assist with technical problems but none were experienced.

A week after students had used the CAL package a short test was delivered during the scheduled lecture slot that week. The test consisted of a variety of closed questions which tested students' knowledge and understanding of the material which had been covered in the CAL lecture (Appendix 21). The tests were scored, the maximum possible score being twenty. Scores achieved in the test varied between 5 and 19 with a mean score of 11 and standard deviation of 3.27.

Learning Styles

To explore whether learning outcomes were influenced by dominant learning style groups, a one-way ANOVA was conducted. Results from the statistical output are provided in Table 11.12. The variable 'Score' was created to measure the tutorial effect (i.e. the performance in the test) for each of the four learning style groups which were the dominant learning styles exhibited by learners as determined by the Gregorc Learning Style Delineator.
The style groups identified by the Gregorc Delineator are:

AS - Abstract Sequential

AR - Abstract Random

CS - Concrete Sequential

CR - Concrete Random

A discussion of these style is provided in Chapter Five.

Table 11.12 ANOVA Summary Table for Dominant Learning Styles Group by Learning Outcome

ANOVA

Learning Style	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
AR	19	9.3684	2.4768	.5682	8.1746	10.5622	5.00	16.00
AS	18	12.9444	3.3514	.7899	11.2778	14.6111	7.00	19.00
CR	15	10.6667	2.7946	.7216	9.1191	12.2142	6.00	17.00
CS	15	11.0667	3.5349	.9127	9.1091	13.0242	7.00	18.00
Total	67	11.0000	3.2706	.3996	10.2022	11.7978	5.00	19.00

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	120.368	3	40.123	4.316	.008
Within Groups	585.632	63	9.296		
Total	706.000	66			

The higher the mean score recorded for each style the higher the benefit having been derived from using the CAL courseware. It is interesting to note that from the overall scores recorded for the different groups the Abstract Sequential group appeared to have gained the most benefit from using the CAL package. (Mean score of 12.94). The Abstract Random group appears to have performed worst (Mean score of 9.37). The result of the analysis between groups showed a significance of 0.008 which was within the $p<0.05$ limit. TheTukey post hoc test was thus applied in order to establish the significant factors which led to a significant result being recorded in the ANOVA. This is presented in Table 11.13

Table 11.13 Tukey Post Hoc test on Dominant Learning Styles Grouped by Learning Outcomes

Post Hoc Tests

Multiple Comparisons

Dependent Variable: SCORE

Tukey HSD

(I) Learning Styles	(J) Learning Styles	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
AR	AS	-3.5760(*)	1.0028	.004	-6.2225	-.9296
	CR	-1.2982	1.0531	.609	-4.0773	1.4808
	CS	-1.6982	1.0531	.379	-4.4773	1.0808
AS	AR	3.5760(*)	1.0028	.004	.9296	6.2225
	CR	2.2778	1.0659	.153	-.5351	5.0907
	CS	1.8778	1.0659	.301	-.9351	4.6907
CR	AR	1.2982	1.0531	.609	-1.4808	4.0773
	AS	-2.2778	1.0659	.153	-5.0907	.5351
	CS	-.4000	1.1133	.984	-3.3380	2.5380
CS	AR	1.6982	1.0531	.379	-1.0808	4.4773
	AS	-1.8778	1.0659	.301	-4.6907	.9351
	CR	.4000	1.1133	.984	-2.5380	3.3380

* The mean difference is significant at the .05 level.

The data in Table 11.13 reveals significant differences in the mean scores recorded for the groups when they were differentiated by learning style. The Tukey test confirms that there is a significant difference between Abstract Sequential learners and learners displaying other styles (notably the Abstract Random group where the result is significant at the $p < 0.05$ level). This lends weight to the belief that learning style is a significant variable which should be considered when implementing CAL systems in higher education.

Furthermore this can be contrasted with performance in lectures only by referring back to the scores in the test in which students self selected to use CAL or attend the traditional lecture (Section 11.2.4.1 - in particular Table 11.11). A one way ANOVA was used to analyse the performance of individual students who undertook to study by attending the lecture. The results are presented in Table 11.14.

TABLE 11. 14 ANOVA Test Scores for Students Undertaking a Lecture based on categorisation by Learning Style

ANOVA

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
AR	8	9.9167	2.3533	.6793	8.4215	11.4119	6.00	14.00
AS	11	9.1111	1.4530	.4843	7.9943	10.2280	7.00	12.00
CR	8	11.8571	1.8645	.7047	10.1328	13.5815	9.00	14.00
CS	5	12.0000	4.2426	2.1213	5.2490	18.7510	9.00	18.00
Total	32	10.3750	2.5113	.4439	9.4696	11.2804	6.00	18.00

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	42.837	3	14.279	2.619	.070
Within Groups	152.663	28	5.452		
Total	195.500	31			

Although the results are not significant at the $p<0.05$ level, examining the average scores achieved by the different learning style groups it can be seen that the Concrete Random and Concrete Sequential both scored higher than the Abstract Randoms and Abstract Sequentials. The AS group in fact performed least well in the test following a lecture. Thus it appears that the difference in performance between learners can be attributed as being caused by the fact that a different mode of teaching was used.

Thus the hypothesis that there is no significant difference in performance when using CAL based materials amongst students with different learning styles should be rejected in this case.

Computer Confidence/Comfort

The results from the test were also correlated with students' degree of confidence using computers. Student confidence with use of computers as measured by the Basic IT skills questionnaire supplemented by the Attitude to Computers questionnaire had been used to categorise students in one of four categories: novice, familiar, experienced or expert. (See Section 11.2.3.3) The variable score again refers to the score achieved by students in the test conducted after they had used the CAL based lecture materials (i.e. the scores from tests described in this section).

An ANOVA test was again used to determine any significant variance between means when comparing the mean scores achieved by each of the categories used to describe computer confidence. The output from the test which was conducted using SPSS is presented in Table 11.15 below.

Table 11.15 ANOVA Summary Table for Computer Confidence by Learning Outcome

ANOVA

SCORE

Computer Confidence	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Novice	16	10.6250	3.0957	.7739	8.9754	12.2746	6.00	17.00
Familiar	24	11.2083	3.4638	.7071	9.7457	12.6710	6.00	19.00
Experienced	13	10.3846	2.6938	.7471	8.7568	12.0124	7.00	15.00
Expert	14	11.6429	3.7746	1.0088	9.4635	13.8222	5.00	18.00
Total	67	11.0000	3.2706	.3996	10.2022	11.7978	5.00	19.00

ANOVA

SCORE

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14.000	3	4.667	.425	.736
Within Groups	692.000	63	10.984		
Total	706.000	66			

The data presented in Table 11.15 shows that there is little variation in learner performance overall. The overall mean for the test was 11.00 and all four groups as defined by level of computer comfort were within a point of the average (10.38 to 11.64). It is interesting to note that although students who rated themselves as most confident in using the computer were ranked above other groups in terms of the average score achieved in the test there was no correlation of average result and level of confidence across the novice, familiar, and fairly familiar groups. Overall the differences between groups was not significant (and hence a post test was obviously unnecessary).

The hypothesis that there is no significant difference in performance when using CAL based materials between students with different attitudes to using computers should be affirmed.

11.3 Tests using CAL courseware designed to deliver practical skills

This final section of the summative evaluation is concerned with the independent use of CAL courseware which provided additional material to supplement student use of their practical course in bibliographic classification. The research question and hypothesis to be tested are as outlined in section 11.1.

11.3.1 Context and implementation of the study

In this study the CAL courseware dealing with practical classification was introduced to students during scheduled classes at the beginning of their study of the Bibliographic Standards Module. During this module all undergraduate 2nd stage students were given a five week course of study on practical classification (designed to cover all major aspects of the Dewey Decimal Classification Scheme). The cohort consisted of 21 students. Students were encouraged to study independently and practise using additional study materials in the form of CAL materials while the course was delivered and in the two weeks after that part of the course was complete (prior to a scheduled class test on practical skills in using the Dewey Decimal Classification Scheme). All students were expected to make use of the courseware. The CAL courseware was based on the same themes as were developed in practical workshops on the topic which were led by the researcher. However, because of constraints on time the tutor led practical workshops did not offer the students the same possibilities for practising their skills and far fewer examples of practical classification could be presented in the workshops.

The relevant parts of the CAL package developed and formatively assessed as part of the research were placed on the hard drives of computers in a 12 computer laboratory. No attempt was made to maintain detailed tracking of how the students made use of the packages. It was considered that patterns of use had been explored in sufficient detail during formative evaluation and that furthermore the tracking itself would have been extremely complex to monitor over the extensive period of time in which the students could use the courseware. In order to gauge level of use, students were asked to keep a log of when they used the practical packages and submit this prior to undertaking the assessment for the module.

Following the evaluation framework presented in Chapter Eight, no detailed profiling of students was required in this study in order to test the validity of the hypothesis. The courseware was made available to all members of the cohort as a supplement to their normal course of study. It could be assumed that the level of computer confidence amongst the cohort was high (the students already having successfully completed a module on information technology which covered use of applications software, hardware and networks in some detail). The main motivation to use the material was extrinsic in that the students were all aware that the material would be useful for the practical test in bibliographic classification which was an integral part of the module and which contributed 50% of their overall mark for the module.

At the end of the period of use all students undertook the practical test and this test was exactly comparable with the practical tests which had been administered for the same module over the previous three years.

11.3.2 Testing the research hypothesis – Hypothesis 4

The performance of the cohort of students who had been provided with the opportunity to use the CAL courseware was compared with those of a previous cohort in order to test the hypothesis:

That there is a significant difference in practical performance in bibliographic classification which can be attributed to the use of CAL based materials as a supplement to practical workshops

The results were correlated with student performance in an exactly comparable assessment which had been undertaken by second year students on the same course in the academic session two years previously. That is, performance of the group of students in the 1998 cohort who were being tested (n=21) was analysed with respect to the performance of the 1996 cohort of students (n=27). (This was because the 1997 cohort had been involved in formative assessment and use of parts of the CAL package and thus they were not deemed suitable as a 'benchmark' group for comparison). The course as delivered to both the experimental cohort and to the control group cohort was exactly the same with the exception of the introduction of the supplementary CAL based material for the students in the experimental cohort.

It should be noted that of the 21 students in the experimental cohort only 17 had logged use of the system. Of the five students who had not used the courseware one also did not complete the assessment for the module. This was not deemed to be atypical of studies which seek to introduce courseware as a supplement to the traditional taught course but it should be noted that, whilst the reasons given for failure to take up the courseware are often attributed to poor implementation, in this case the students had been given a full induction on how to use the courseware and were, at that time, aware of its importance to assist them in their assessment.

An independent samples t-test was conducted in order to compare the overall average and distribution of the mean score between the group of students who had used the CAL materials and those students from the control cohort who had not. Students in the experimental cohort who had been given the opportunity to used CAL materials but had not availed themselves of this opportunity were included in the statistical analysis (4 students). In the statistical analysis the independent variable was access to the courseware and the dependant variable was the score achievement in the summative assessment for the test on bibliographic classification conducted as an integral part of the taught module. The assumption was made that general level of ability in each of the cohorts was comparable and this was qualitatively confirmed by the researcher through observation of the learning strategies adopted by students and formative evaluation of their progress in understanding the practical material. The tests for both cohorts were marked by the researcher but in order to ensure that there was no bias the results of the 1996 cohort were only retrieved for analysis after the 1998 cohort marks had been completed. In addition, because the test is one which is objective (scores are awarded on the basis of the student having demonstrated a practical understanding of particular classificatory techniques) the robustness of the test as an instrument for the comparison was assured. The results of the analysis are presented in Table 11.16.

Table 11.16 Independent Samples t-Test comparing scores on practical classification assessment

Group Statistics

	Cohort	N	Mean	Std. Deviation	Std. Error Mean
Score on Practical Classification Examination	Previous Cohort (1996)	27	53.41	17.95	3.45
	Current Cohort (1998)	20	56.35	22.03	4.93

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Score on Practical Classification Examination	Equal variances assumed	1.676	.202	-.504	45	.616	-2.94	5.83	-14.69	8.81
	Equal variances not assumed			-.489	35.935	.628	-2.94	6.02	-15.14	9.26

Although it can be seen that there was an overall increase in the average mark attained by students (53.41 to 56.35) the t-test shows that this should not be considered significant ($p = 0.202$).

Thus the hypothesis that there is a significant difference in practical performance in bibliographic classification which can be attributed to use of CAL based materials as a supplement to practical workshops should be rejected

11.3.3 Student Feedback

As has been noted previously in an experiment which involves additional resources it would be likely that some gain in the quality of learning would be evident. An important aspect of examining the particular research question posed in this study, irrespective of whether a gain in learning effect is evident, is to investigate the attitude of students who were provided with access to the resource in order to determine how they used the materials and to establish whether there is a causal link between learning improvement and the introduction of the courseware.

The undergraduate students who had been provided with access to the CAL courseware were interviewed at the end of the semester in a group feedback session in order to determine how useful they had perceived the CAL material to be and how much use they had made of it. Four of the twenty students in the cohort did not actually make any use of the CAL courseware and also did not attend the scheduled class session at which feedback was provided by students on their perception of the value of the courseware. The following analysis is therefore based on comments from 17 students.

Four students stated that they had used the courseware regularly (generally immediately following the practical workshop). The majority of the students (nine) stated that they tended to use the package only when they felt they were having difficulties with the material covered in the practical workshops or felt they did not have time to complete the work during the practical workshop. The other four students stated that they had only really looked over the material quickly but had not seriously studied using the material.

The analysis of the discussion of how they rated using the courseware has been provided in a format which discusses issues which appeared to indicate a negative response to either the CAL material itself or how the students accessed it and a section which lists positive responses. Numbers of responses are generally not given because the feedback was conducted through open class discussion. At the end of the session, however, the main points were summarised by the lecturer and there was general agreement on most of them. Where there was not full or majority agreement it is noted that no consensus was achieved. Table 11.17 shows the outcome of the student feedback.

Table 11.17 Structured Feedback from Undergraduate Students on use of CAL courseware

Negative Responses	1. Not enough time to devote to make full use of the CAL courseware (Note: this was a point in which all students were in complete agreement) 2. Too complicated to try to study the CAL material without the schedules of classification (Note: - clarification was sought on this as these could have been used by students but because they are bulky and the computer laboratory workstation space is limited it was problematic to try to use them in the laboratory) 3. Laboratories too busy at times when it would have been convenient to use the courseware 4. Too much repetition between courseware and the practical classes (no consensus) 5. Frustrating when using the CAL material not to be able to get tutor's help 6. Some of the examples were too difficult and more explanation was needed (no consensus)
Positive Responses	1. Very useful to be able to check understanding of practical sessions particularly where the examples given seemed to be very complicated 2. Good to be able to take time over working out how to do things 3. Good range of easy and difficult questions (no consensus) 4. Able to see from the worked examples how to go doing the examples on your own 5. A change from the usual way of having to sit and listen to someone explaining things (3 students)

11.3.3.1 Discussion of Feedback

The CAL courseware obviously led to some gains in knowledge and understanding but there were a significant number of contextual issues which affected the manner in which students used the resource and which also affected their perception of its value. It was interesting to note that most of the negative issues were related to the environment in which the courseware was used rather than with the courseware itself. The other salient point which comes out of the analysis of the student responses is that overall the use of the courseware was very low. This was despite the fact that students were given adequate direction in how to use the material and every effort was made to remind them that it would be to their advantage to use the courseware. This finding was not, however, particularly surprising and, as has already been noted reflects the experience of other implementations of CAL in higher education. The tone of the meeting with the students which is often difficult to encapsulate in a simple analysis of student responses, was very positive and in general the students were self-critical of their failure to take advantage of the CAL courseware but stressed the need to balance the amount of work which they had to do overall in the four units which they were studying. None of them were in any doubt what the purpose was of the CAL courseware and generally they felt that it achieved its aims and objectives as a useful teaching aid although as one student commented:

'it doesn't really matter how wonderful the teaching is if you don't really feel you have the time to get to grips with it'

and another echoing this sentiment directed the comment to the researcher that:

'what you have to understand is that 'when we feel we have what we need to get through a subject it's difficult to get up any enthusiasm for doing extra'.

One student suggested that perhaps the whole module could have been delivered by just getting students to work through the CAL courseware but this was very much a minority view and overall the students strongly opposed any suggestion that face to face practical workshops could be dispensed with.

11.4 Conclusion

As suggested by the evaluation framework which was developed and discussed in the first part of this thesis, the CAL courseware developments which were intended to replace some face to face teaching had to be examined rigorously. This meant not only determining that overall they were as effective as the teaching which they were replacing in terms of overall outcome from student assessment, but that a profile of the learners was developed and issues related to individual differences were thoroughly examined. The self selection process undertaken to examine the question of whether students overall fared equally well using CAL as when attending a traditional lecture raised some interesting issues related to the self selection itself but overall the performance of students in either mode of teaching was not significantly different. In examining the second and third research questions it was surprising to find that, although overall level of computer comfort/confidence was not significant as a factor in determining how well students performed using CAL, learning style (in particular Abstract Sequential learning style as measured by the Gregorc Style Delineator) had a significant impact on performance. Possible explanations for these findings, and whether they are unique to the courseware being tested or may represent more general conclusions, are discussed in Chapter Twelve

Finally the reaction of students to using courseware as a supplementary teaching resource clearly demonstrated that whilst a small learning effect may be seen overall when performance of students is examined that other considerations require attention if CAL courseware is to achieve the level of success which many commentators predict for it. In particular the contextual issues surrounding the use of the courseware and the requirement to ensure that students engage effectively with it are going to be of critical importance in ensuring that CAL courseware will have the impact on student learning which many believe it is still capable of having.

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Chapter Twelve

Discussion and Conclusions

> *He that will not apply new remedies must expect new evils; for time is the greatest innovator.*
>
> ***(Bacon, Essays 'Of Innovations')***

12.0 Objectives

In reviewing the literature and conducting the programme of practical work involved in evaluating multimedia CAL in this research a number of important themes have been raised. The purpose is of this Chapter is to examine these themes and discuss in detail the key points which have emerged both when developing and adopting the framework for evaluation and adopting the framework during an empirical study involving the development and evaluation of CAL courseware.

Specifically the objectives of this chapter will be to discuss:

- deficiencies in current approaches to evaluation which are evident in the literature and highlight the way in which using the framework developed as part of this research in order to evaluate CAL can overcome some of these problems
- the key issue of learner attitudes to CAL and in particular the relationship of these attitudes and of learner differences to the evaluation process in the light of the findings of the current research

- the relevance of the current research to future developments and a possible future research agenda for developing and implementing CAL in higher education

The development of robust evaluation techniques and the need for ongoing evaluation is seen by most commentators as being of vital importance in developing high quality computer assisted learning packages for use in higher education (though increasingly the focus of the applications is as web enabled documents for delivery to learners in distance mode). However, the manner in which such packages have been evaluated shows considerable variation and there is ample evidence of a very confused approach being taken. The first question which must be addressed is why evaluation is being done. In some cases there is justification for being somewhat cynical about motives for evaluation and view the evaluation as a procedure which is conducted to justify the effort which has been expended in producing learning resources – particularly where such resources have been the output from a funded project. Likewise statements such as the following from a recent book on the subject do not inspire confidence:

> *In the academic environment there are important added advantages of a thorough approach to evaluation, since the results can be used as research output, as well as in funding applications (Phillips, 1997)*

The primary reason for engaging in evaluation should be to ensure that the courseware which has been is effective in terms of improving the quality of learning or the efficiency of teaching. However, it has also been noted that the manner in which individuals and project groups define what they mean by effectiveness may vary. In some cases this may be based on increase in subject specific skills or knowledge or in others on acquisition of generic or transferable skills. In some studies the courseware is developed as part of a general move towards resource based learning or in some cases as a support for discovery based learning. Often there are explicit economic considerations such as effective delivery to larger and diverse cohorts or use of multimedia techniques to replicate or simulate expensive or dangerous 'real life' experiments. These different strategies for development of instructional systems reflect the variety of approaches to research in instructional technology. As Richey notes:

> *'Some instructional technologists argue their goal is the creation of resources and environments for **learning**. Others argue their work is directed towards **performance improvement**. Others suggest the goal is **organizational improvement**.' (Richey, 1994)*

Thus it is important to emphasize that evaluation must be based on the explicit statement of educational objectives which have been made for the courseware which has been developed or which is being implemented. Post hoc rationalisations of benefits of using the courseware which are not firmly based on the aims and objectives of the courseware should not be considered as contributing to an evaluation.

Furthermore, any evaluation is clearly going to be very much influenced by a range of contextual issues. Some of these issues may be a function of the design of the courseware itself – e.g. a piece of courseware which has been designed as a 'remedial guide' or courseware designed for 'extension studies'. Obviously such courseware should be evaluated primarily in the context in which it meets the needs of its stated target audience rather than being the subject of evaluation studies which attempt to broaden the context in which the courseware is used without acknowledging the implicit pedagogical aims which were the basis for development of the courseware. Nonetheless there are a number of examples in the literature where 'courseware' designed for a particular audience has been evaluated outwith that context and, not surprisingly, the evaluation 'discovers' issues concerning usability. This is particularly apparent in a number of studies which have examined the use of commercial products which were designed as reference tools and which have been evaluated as 'teaching packages'. In part this is something which is promoted by the producers of such material who are all too willing to make claims about the breadth of situations in which their product can be used.[1] This is not to say, of course, that it is not valid to look at extension of the use of courseware to areas other than those in which they were originally developed. However, when this is done it is important to stay clearly focused on the original parameters which proscribed the development and use of the material and ensure that the evaluation is not critical of the ability of courseware to support or enhance learning in contexts in which it was not designed to be used. Thus the primary focus of the evaluation framework which has been developed as part of this research is to ensure that purpose is clearly defined and determines the strategy of evaluation throughout the stages from development to final summative evaluation in an authentic learning situation.

The other important feature of the evaluation framework is an explicit recognition of evaluation

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[1] *See for example the claims made by the producers of the Grolier Multimedia Encyclopaedia in their web site for the use of the encyclopaedia as a 'teaching aid'.*

as an ongoing activity that needs to permeate the development of courseware and both formative and summative evaluation stages. Evaluation should not be narrowly focused on outcomes in terms of student attainment or 'overall learning effects' though these obviously must be measured if the developers of courseware are making claims with regard to enhancements to student learning. Affective issues and context are as important as the educational outcomes. However, in the literature dealing with evaluation this dichotomy between learner attitudes and perceptions and the learner performance can be seen to have given rise to considerable confusion and generated a debate on how exactly evaluation should be conducted. At its most stark this can be seen as giving rise to a debate on the relative merits of qualitative and quantitative approaches. It is also evident in the debate about the value of comparative studies which seek to demonstrate that approaches using CAL provide 'better' results than 'traditional learning' and in the current discussion in the literature about the merits of 'illuminative' and 'integrative' evaluation strategies. Crompton contends that there are two distinct approaches to evaluation and he labels these as the 'agricultural/botanical or scientific approach' and the 'social/anthropological or illuminative approach' but also notes that though these are at either end of a continuum it is possible to make use of both of them in educational research. (Crompton, 1999)

However, this must not be interpreted as a statement which implies that evaluators can be totally free in the type of approach they choose to adopt. If the aim is to take an holistic approach to evaluation a variety of strategies need to be adopted but within a particular evaluation it is important to look at the specific situation and depending on the objectives of the courseware there may be explicit requirements to provide some form of quantitative 'evidence' to show that the objectives of the evaluation have been met.

The argument within the context in which the framework has been constructed is that this must be done purposively. It is important to take a more structured view than appears to be advocated by some authors. Thus, for example, when discussing evaluation of multimedia CAL Phillips contends that :

> *'the key point is to collect as much data as possible for review and reflection and to report them to others when presenting information about the history and development cycle of the product (Phillips, 1997)*

This type of approach can give rise to confusion and a lack of clarity in the reported evaluation will be the inevitable result. Evaluation is the collection, analysis and interpretation of information about any aspect of a program of education or training as part of a recognised process of judging its worth. The data which is collected, therefore, and the techniques used to ensure that the data is correctly interpreted must contribute towards an examination of what has originally been agreed as the 'worth' of the project. There is still a reluctance on the part of some commentators, however, to accept the consequences of this approach. Thus, for example, Ling, commenting on the approach of using goals or objectives of a project as the basis for evaluation suggests that

> *'this approach is suitable if the objectives of the particular innovation have been accepted as being worthwhile, unanticipated outcomes are seen as irrelevant and costs are seen as given and acceptable. This is at least prima facie, the situation which applies to some specially funded projects, such as projects funded by a university ... even in this situation, however, to evaluate a project against its own objectives is limiting' (Ling, 1997)*

This , however, seems to ignore the fact that not only does the basis for the evaluation (and hence the data to support any contentions which arise out of evaluation) lie in the statement of purpose for development and use of CAL but it is almost certain that the reason for funding being provided was also concomitant on these objectives being achieved. If, as Ling suggests, the objectives of a particular funded project are not seen by developers to be suitable the whole question of why the development is being undertaken needs to be examined. It is not sufficient, however, to simply determine that the focus of evaluation will shift to examining what the evaluators feel may have been more 'worthwhile' objectives. At the risk of over-labouring this point, whilst there is merit in noting the significance of factors which have been determined through what Draper et al. term 'surprise detection' (Draper, 1996) this must not be allowed to detract from the fact that methodologically in any evaluation the objectives of the intervention must be the central focus to provide purpose and direction to what has to be achieved in terms of evaluation. The element of 'surprise'can arise naturally in an evaluation situation whilst objectives are being pursued and certainly it would be foolish to ignore extraneous benefits or understandings which can inform future action. But these must not be allowed to detract from a strategy which rigorously seeks to determine a research question associated with the introduction of a novel approach to teaching and objectively report on whether or not the question can be answered fully given the available data.

Data must be collected purposively to support the fact that the aims and objectives of the courseware are being met and in order to facilitate this the evaluation framework which has been provided seeks to clearly identify the data needs for different stages in an 'evaluation life cycle' which encompasses development, formative and summative evaluation. The main point made in respect of this is that broadly speaking the function of data collection within the three stages of evaluation is evidence to support the following:

Development:	the robustness of the system itself and the adequacy of the interface which has been provided for supporting students in interacting meaningfully with the content of the learning package
Formative evaluation	student perception of usefulness of the material itself and the manner in which it is presented. General evidence about the manner in which students interact with the courseware and use it to support their learning – this is particularly important if inferences about a causal relationship between the use of the courseware and 'improved student performance' is to be established
Summative evaluation	evidence that the implementation of the courseware in an authentic setting realised the aims and objective for production of the courseware – whether this be in terms of improvements in the quality of student learning or enhancements in the effectiveness of delivery

All of these activities are important in supporting an evaluation of the usefulness of any educational intervention and are particularly important when examining CAL.

12.1 Problems with current evaluation practice and research into CAL

Some of the problems of evaluation practice can be seen to be inextricably linked with a number of the misconceptions about the actual and potential use of multimedia CAL in higher education that are evident in the literature. Two of the main arguments for multimedia CAL as described in Chapter Four appears to lie firstly in the ability to present the user with multiple media in representing subjects to be learned and secondly on the possibility of providing a high level of potential for interacting with the learning material and constructing a personal path through the learning material.. The empirical tests conducted in the second part of the thesis and described in Chapter Ten do not support either of these claims. Furthermore, in the survey conducted in this research (described in Chapter Seven) which reviewed the manner in which CAL packages have been developed and implemented there do not appear to be many intrinsic qualities of computer based learning which in themselves can be seen to engender 'deep' or meaningful learning

12.1.1 The media and learning debate

The most important point to make in this respect is that if multimedia CAL is evaluated purely in terms of the medium used for delivering higher education and attempting to explain the merits of this approach solely from the perspective of the capacity of the computer as a platform for delivery then the evaluation will not be successful.

Within the context of the courseware developed as part of this research it was found that the use of sound needs to be very carefully considered and this medium should only be used where it is of intrinsic value to the content of the courseware being developed. (This was confirmed not only in the student reaction to the courseware developed as part of this research but also during the survey of CAL courseware which is described in Chapter Seven). Likewise, the empirical work shows that there is little support for the view that additional media (in the form of graphics) provides anything more than a temporary aid to assisting recall of facts. In the immediate and delayed tests on ability to correctly allocate subjects to the appropriate one of ten groupings used by the Dewey Decimal Classification Scheme, the use of graphics was found to result only in a short term improvement in performance. It would appear also, from some of the feedback derived from formative evaluation in the development of the courseware as part of this research, that a more important reason for inclusion of graphics (and perhaps other media types) is that, taken as intrinsic design features they contribute to students' sense of the worth of the package (even as was noted in Chapter Nine when there is no particular pedagogic imperative for using the graphics). The media and learning debate (Clark, 1985; Kozma, 1991; 1994) which has concentrated for over ten years on discussing 'whether' media influences learning should now concentrate more on student perception of the value of media and the factors which influence this rather than any intrinsic qualities of the media used.

The arguments surrounding CAL in higher education, therefore, should not be reduced to simple questions about the inherent benefits of the medium used. Proponents of the computer like to quote the fact that Socrates was violently opposed to the use of books in learning claiming that they stifled learning. The subtext of such an assertion is that criticism of the computer as a vehicle for delivering learning is based on a reactionary prejudice to 'new media'. However, purely from the perspective of the medium used there are more serious grounds for questioning the use of computers in delivering teaching. The book has been long established as a learning tool in higher education and there has been a long tradition of developing a rhetoric for written communication which supports delivery of clear communication using the medium. Although computers are certainly no longer to be regarded as a novelty in higher education there is still a substantial reaction against their use – both by staff and by students. Whilst it would be unthinkable not to support a university programme of lectures and seminars with readings we are only now beginning to see the more widespread application of the Internet as a support tool. However, there is still – despite a large investment of funding in the TLTP initiative- very little support for the integration of electronic books or tutorials into the delivery of higher education. Research on the use of technology in education needs to focus much more sharply on examining human computer interaction and developing a 'rhetoric for hypermedia' in order to support a learning environment in which increasingly more information will be absorbed by learners via some form of computer interface.

12.1.2 Learner control and support for cognitivist approaches to learning

Examining the second claim for multimedia CAL i.e. that CAL provides learners with the opportunity to personalize their use of the material and take more control of their learning by deciding the order in which they wish to study or review topics again it should be noted that the empirical research demonstrates little to support the view that in an authentic learning environment this is in fact the case. In making use of the courseware designed to replace lectures students seldom displayed patterns of interactivity which did not reflect a linear sequential approach to the material.

Learner control has been one of the most heavily researched dimensions of computer assisted learning. (Steinberg, 1989; Williams, 1993). Learner control is defined as those design features of CAL which enable learners to choose freely the path, rate, content, and nature of their instruction. (As such this is often contrasted with program control i.e. design features in the CAL application which explicitly determine the path of instruction). The quality of research in this area of investigation, however, has been severely criticised. Reeves reviews some of the research and justifiably comes to the conclusion that:

> *'... learner control research studies are flawed in terms of theoretical and methodological issues. Fundamental problems arising from the failure to adhere to the tenets of the quantitative paradigm suggests that much learner control research is largely pseudoscience. Some telltale signs of pseudoscience in CBI research include: vague definitions of the primary research variables; insufficient efforts to relate research hypotheses to robust learning or instructional theory; cursory literature reviews narrowly focussed on the results of studies closely related to the one being conducted; emphasis on easy to measure variables (e.g. time) to very precise levels (e.g. microseconds) and a lack of emphasis on the reliability and validity of instruments used to assess difficult to measure variables (e.g. learning); applications of obscure statistical procedures in hopes of discovering some meaningful relationships among the variables when predicated main effects are not found; and rambling incoherent rationales for failing to find statistically significant differences' (Reeves, 1993)*

Furthermore there is an important assumption in learner control research which needs to be clarified. The assumption is that given greater control over learning results in greater achievement. As Milheim and Martin note:

> *Few studies have reported a theoretical framework for understanding why it may be effective to allow students to have some control over the learning process (Milheim and Martin).*

Moreover, authors such as Laurillard and Plowman argue strongly against providing complete freedom to learners and stress the importance of narrative in courseware (Laurillard, 1995; Plowman, 1996).

It should be noted that the empirical studies conducted as part of this research and reported in Chapter Ten did not set out to look in detail at learner control but did used tracking mechanisms during formative evaluation to record the manner in which students interacted with the courseware. Obviously in didactic teaching involving novice learners the scope for interactivity using CAL is very limited and users tend to follow the 'prescribed' linear path in order to develop their knowledge and understanding of a topic. This adoption of a linear approach was particularly obvious in the tracking logs of courseware used by postgraduate students (discussed in Section 10.3.1.4). The navigation style used by corresponds with the manner in which it might intuitively be expected that such courseware would be used (following the same type of cues which are involved in learning from printed text). Thus it is not surprising that Beasley and Waugh in their study of navigation patterns should conclude that:

> *'It was found that participants tended to employ a systematic, top down, left to right (depth first) navigation strategy to ensure full overage of the lesson material initially and then covered the material in a much more spotty and less systematic manner during review' (Beasley and Waugh, 1997)*

In the formative evaluation presented in Chapter Ten it was noted that when examining the use of the courseware material designed to teach practical skills in which 'drill and practice' and increasing task complexity is built into the CAL material there is evidence that students vary in the degree to which they interact with the material. In some cases this was demonstrated in the general approach they adopt to gaining practical skills, some preferring to adopt an approach which builds firstly on an understanding of the theory, others preferring to adopt approaches which either begin with a study of worked examples and yet others adopting an approach of learning by doing and attempting to solve test examples). Discussion of the reason for such strategies with students revealed that by far the major factor influencing the strategy which they adopted was the time which they felt they could adopt to studying the material. Detailed tracking was not included at the summative evaluation stage. In retrospect it might be argued that this could have given a much more accurate picture of how students used the courseware but as was evident from feedback from students in Chapter 11 the over-riding issue in this study was the problem of integration of the material into their course and the impetus for students to use the courseware at all.

The area of study in this research has been the use of CAL courseware as a didactic tool rather than as a source of reference or remedial assistance (although doubtless the materials could be used in that context). Whilst it would have been interesting to follow up the manner in which students interacted with the material in different contexts this would have involved a quite different line of research. The thrust of the investigation would then have had to be an examination of information skills and information searching strategies. This is a vital area of research and obviously germane to illuminating the way in which students gather information to support their learning or to support completion of a particular task which they have been assigned. However, in this research the objective of the courseware designed as part of this research was to assist the directed or independent study of a particular topic and thus, an following the framework outlined in Chapter Eight, the evaluation had to be designed with this in mind.

A better theoretical framework for learner control research is required as is a much greater concentration on examining the particular circumstances and reasons for the outcomes which are reported in learner control studies. Furthermore, if such studies are to provide an insight into student learning they must be conducted in an authentic environment and they must very clearly delineate the context in which the CAL courseware was designed to be used.

Finally in examining learner control it could be argued that one of the most significant controls which a learner can exercise over how to study is whether or not he/she in fact makes use of the materials at all. It could be argued that the students who undertook the course in practical classification were provided with the most significant learner control choice – i.e. an option to use the material for study or not to. The fact that students chose not to make extensive use of the material was not a direct reflection of student perception of the value of the material but has to be considered in the context of the overall learning environment and competing demands on student time. The outcome of the study involving the development of courseware to supplement practical instruction in bibliographic classification emphasized the crucial importance of context of implementation to the success or otherwise of computer assisted learning. This very much supports the view of a number of authors that the context in which the courseware is used is often the major factor in determining the success or otherwise as reported in evaluation studies (Draper, 1996; Milne and Heath, 1997; Oliver; 1998; Oliver and Conole, 1999). It also confirms the value of including a requirement to include contextual objectives related to delivery of the courseware within the evaluation framework which has been developed as part of this research.

Linked frequently to the argument that CAL can provide more user control over learning is the argument that CAL can thus support a more cognitivist approach to learning. The ultimate expression of this view is that students can construct their own learning using resource rich learning environments. Such arguments are often an explicit rebuttal of early criticism of CAL systems as being based on a discredited behaviourist pedagogy. Behaviourist theories of learning seek scientific, demonstrable explanations for simple behaviours. For these reasons, and since humans are considered to resemble machines, behaviourist explanations tend to be somewhat mechanical in nature. Critics of behaviorism state that it oversimplifies human behaviour and sees the learner as an automaton rather than being a creature with a will and purpose. This criticism is just if we examine only the extremes of behaviourism but it should be ameliorated by stating that it is very rarely the case that these extremes are evident in courseware which is currently being developed. Behaviourism has had a major influence in instructional design theory and in instructional design practice it continues to be very influential but the most pedagogically unsound examples of instructional design based on behaviourism – such as simple drill and practice programs or highly programmed learning approaches to enforcing the memorisation and replication of facts – are no longer at all common. Behaviourism is not in itself a completely discredited pedagogic theory. However, there appears to be a tendency in the literature to emphasise the cognitivist and constructivist potential of multimedia CAL and this has the effect of producing a somewhat distorted picture of the types of courseware which are being developed and used in practice. The survey of CAL software and questionnaire survey of CAL producers has provided evidence to confirm the view that despite much theorising about the benefits of cognitivist and constructivist learning environments many CAL packages which are currently being developed and used exhibit a predominantly behaviourist approach in their pedagogical design. Where this is the case it is important that the developers of such material make this explicit in a statement of aims and objectives for the courseware. In doing so the courseware can then be appropriately evaluated using tools which measure observable changes in behaviour or performance.

Significantly in the evaluation framework the point is made that if the objective of introducing multimedia CAL courseware is to promote a cognitivist approach to learning then this must be reflected in the evaluation of the courseware and suitable instruments to measure cognitive changes in learners must be adopted. There is an indication from the literature that some such tools are available (e.g. through use of the SOLO framework discussed in Chapter Eight), however, an analysis of the literature does not support the case that they have been used to any great extent in evaluations. The problem of developing tools to measure cognitive changes is even more evident when one considers the evaluation of constructivist environments which make quite radical claims to supporting students cognitive skills. The literature contends that support is given to learners to help them to construct their own reality (or at least interpret it) based on their own perceptions and experience and build mental structures and beliefs to interpret and contextualise what they learn. It is interesting to note that the support for the constuctivist view and the means by which it engenders learning and in particular the mechanisms by which it can be fostered are in many cases built around the use of multimedia support being provided in the form of video and animations to provide or emulate real life contexts. Thus we appear to come full circle to the view that the medium itself is critical factor in determining the success of the courseware (see, for example, the discussion of seven design principles for constructivist environments proposed by the Cognition and Technology Group at Vanderbilt discussed in Chapter Seven).

As noted above the empirical study which has been conducted in this research has centred on the development of courseware which is didactic in approach and which can broadly be categorised as behaviourist. To an extent this decision was pragmatic and practical. Development of courseware which pursues cognitivist or constructivist goals is extremely complex and could not have been achieved within the context of the research. In addition the principles for evaluation for behaviourist environments in the framework make use of evaluation instruments which have already been established as reliable and fit for purpose. This does not mean, however, that the empirical work has ignored affective issues which are in the literature more prominent in the evaluation of cognitivist scenarios. Adopting a phenomenographic approach to the development and formative evaluation of the courseware as described in Chapters Nine and Ten takes into account many of the significant factors which have to be assessed when examining any pedagogic approach. One of the most significant outcomes of the research, in fact, has been to highlight the central importance of learner attitudes and perceptions when evaluating courseware no matter which pedagogic approach has been adopted.

12.2 The Learner Perspective

From the discussion above, and as is evident when examining the framework for evaluation, it is important to recognise that what is being evaluated is not a system itself but rather the more complex issue of how users interact with a system in order to achieve their goal of developing a skill or learning about a subject. Thus it is important to get out of asking questions about whether or not computers are good for learning and attempting to provide a simple answer in terms of better achievement in test scores or large 'learning effects' as measured in the differential between pre and post tests without considering:

- alternative possibilities which would account for any observed changes in learning outcomes

and

- potential differences between individual student performance which may be associated with the delivery mechanism

A well founded evaluation must be centred on the courseware, the students and the nature of the learning task rather than being concerned with the technological platform on which learning is delivered. As Tergan notes, 'the subject matter, the learner, the instructional methods and the technology all need to be evaluated' (Tergan, 1997). In examining the outcome of any evaluation it should be clear that an assessment of all of these factors has contributed to the results reported. Thus it is important to investigate the learning process itself and to do this in an authentic setting to ensure that the observation of learning can be accurately correlated with any learning effect which is reported. Immediately, however, this approach raises a number of methodological problems. As Reeves notes:

> *'Most of the research in instructional technology is conducted on the basis of the assumption that education is governed by natural laws and therefore can be studied in a manner similar to other natural sciences such as chemistry and biology. As my students can attest, I often question this assumption in my teaching and advising; I have done likewise in my published scholarship (cf Reeves, 1986, Reeves, 1993). As instructional technologists, we have made and continue to make the wring assumptions about the nature of the phenomena we study and hence ask the wrong questions' (Reeves, 1996)*

Notwithstanding this, the framework which has been proposed for evaluation continues to emphasise the importance of some form of 'scientific measure' in order to ensure that the outcome of the evaluation demonstrates any changes in the quality of learning. This should be measured by the same assessment instruments which are used in parts of their course which are not delivered using CAL. It may be the case that such assessment instruments are flawed but without opening up for debate the whole question of how assessment is conducted in higher education it is not reasonable to assume that the courseware will necessarily improve the quality of learning. Thus it is important to avoid the type of situation which Norman and Spohrer criticise in their review of CAL evaluation when they comment that too many studies rely on reports that teachers and students 'liked the system' (Norman and Spohrer, 1996). There tends to be an assumption that where it is the case that students 'like' a particular type of teaching this will inevitably be reflected in better performance. This, however, was certainly not the case in the evaluation of the courseware developed to assist undergraduates develop skills in practical classification. There are potentially a whole range of other contextual variables which will have a more direct impact on assessment outcomes.

In common with many other evaluations, the outcome of the evaluation of the CAL courseware developed to replace lectures delivered to the postgraduate cohort reported 'no significant difference'.[2] However, the evaluation framework also stresses the need to investigate any potentially significant differences caused by individual learner differences in cases where the courseware is being implemented as a substitute for another teaching method. Doing so in the experiments described above demonstrated that there was a significant difference in performance dependent on learning style. The results of this study support the contention that computer assisted learning does not support all learners equally and in particular that in learning style as defined using the Gregorc Style Delineator, Abstract Sequential learners seem to benefit from using CAL, whereas there were changes (though not significant) which seemed to indicate a relative decrease in performance by concrete random and concrete sequential learners. Gender and age were not specifically targeted as variables for investigation in this study. However, the level at which gender reflects learning style should ideally be further investigated as cross tabulations of gender and learning style though not significant showed that a relatively higher number of females exhibited sequential styles than would have been expected from a completely random distribution. No significant differences were detected in performance which could be attributed to differences in the degree of computer confidence of the participants in a test on performance following use of the CAL courseware.

According to Gregorc individual learning styles influence preference for method of instruction. (Gregorc, 1982). As was discussed in Chapter Five Butler and Gregorc (Butler, 1984; Gregorc, 1985) believe that dominance in sequential mediation channels pre-disposes the individual to having a preference for working with, and learning from, computers. Likewise Gregorc and

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[2] *It should, however, be noted that Shutte documents improved learning outcomes using on-line materials without formal lectures and this is view is confirmed by Skillicorn in his description of the implementation of Hyperwave at Queen's University in Kingston Canada and by Davis in et al in their description of the implementation of Microcosm at Southampton University but these measures are based on supplementing other areas of course delivery*

Butler also contend that those learners who exhibit random learning styles could potentially find working with computers problematic. In particular Butler contends that abstract random learners show a preference for engaging in instructional methods which require verbal responses and prefer human contact throughout the learning process. This may well provide an explanation for the significant difference recorded in test scores when using CAL when, as reported in Chapter Eleven, the results of showed a greater difference between the scores achieved by Abstract Sequential and Abstract Random learners than those between any other groups as categorised by learning style. This also accords with findings reported by Davidson et al. where abstract random learners (as defined by the Gregorc Learning Style Delineator) enrolled in a course on computer applications achieved significantly lower results in comparison to learners who exhibited a dominant learning style which placed them within one of the other three learning style quadrants (Davidson, 1992). The study also accords with findings in an exploratory study by Ross. In his study Ross examined the effect of a number of individual learner differences including learning style. Learning style was measured using the Gregorc Style Delineator but an important difference between Ross's study and the tests described in this research is that the experimental treatment which Ross adopted made use of pre and post test scores (Ross, 1997). Abstract Sequential learners achieved a gain of almost four points whereas those exhibiting concrete sequential and concrete random styles only raised their score by approximately 2 points. Significantly, however, the achievement of abstract random learners actually decreased by over two points between the pre and post test. As noted above Ross was performing an exploratory study and there were a number of potential variables which were not closely controlled. In particular the level of prior domain knowledge was considerable different amongst participants in the experiment and the study was conducted using volunteers rather than being placed in an authentic context. Nonetheless, the similarity between the findings between this research and the studies by Ross and Davidson are sufficient to raise concerns that it appears that CAL may not be a medium which is suitable for all learners.

Another major concern which the empirical studies raised relates to some of the attitudinal issues which were revealed in responses by students in feedback sessions which were conducted as part of the formative and summative evaluation of the courseware. Students were generally enthusiastic about the courseware and certainly there was no evidence to suggest that there were any significant difficulties inherent of the design of the courseware which should make use problematic. Examining responses from students overall would accord with Laurillard's perception of courseware implementation when she notes that:

> *'what shines through from even the meanest implementation to any evaluator who is looking is the enthusiasm the media can generate, and naturally, that evidence continues to find expression in the conclusion that the media have potential' (Laurillard, 1994)*

However there were issues which concerned students. A persistent issue was that a small minority of students in all of the cohorts on which the courseware was formatively and summatively tested were uncomfortable with the use of the technology on grounds which appeared to indicate an underlying 'technophobia'. Whilst one might argue that such an attitude is increasingly rare and is certainly not conducive to study at any level in higher education it must be acknowledged that it is a persistent attitudinal problem. The causes of the problem need to be much better researched as should constructive mechanisms to ensure that deep seated anxieties related to use of the computer can be identified and dealt with. While it is easy to dismiss such attitudinal problems when explaining the overall acceptability of a move towards technology it has to be acknowledged that potentially a small group of learners could be alienated by attempts to change teaching methods which rely more heavily on independent computer based learning. In addition it should be noted that a majority of students expressed discomfort about the idea of not having lectures. Again it might be possible to argue that such comments suggest a belief that the formal classes were places where teaching was delivered rather than where learning took place. i.e. situations in which the lecturer did something and they did not. Replacing lectures would thus challenge this belief and places the emphasis on learning. However, it was obvious from the feedback from students that there are many other factors in face to face teaching which, although not based on pedagogically sound precepts, were nonetheless important reasons for preferring to engage in learning involving human interaction and providing the possibility of direct face to face interaction.

As many commentators note technology has to be embedded in the curriculum if it is to make any impact. However, an important pre-cursor to doing this must be to ensure that the technology does not in fact result in a decrease in the quality of learning for some students.

Thus whilst there is ample evidence that in a significant number of cases it is a teaching method which is enthusiastically received by students this must not be allowed to hide the fact that it is not a method which has universal approval. A small but significant minority of students have a persistent aversion to the use of technology in teaching and as the practical studies in the second part of this thesis have shown there is some evidence that CAL does not serve all learners equally.

12.3 Future directions for research into the development and application of CAL

Arising from the above discussion a number of recommendations can be made about future research directions in evaluating multimedia CAL with reference to the framework for evaluation.

- It should be noted that there is still considerable scope for further testing and application of the evaluation framework outlined in Chapter Eight. The empirical studies which have been carried out as part of this research could not cover all of the different aspects of the framework which should be tested and there is considerable scope to do more. Note has already been made of the evaluation of cognitivist learning and in addition the whole issue of cost benefit and cost effectiveness analysis needs to be examined. There is no evidence that development and delivery of CAL courseware is cheaper or easier than delivering face to face instruction. On the contrary, in fact, there are a number of authors who claim that for the equivalent investment of money more traditional teaching methods (involving, for example, enhanced mentoring of students or additional print based resources) would result in more significant gains in student learning. This is a significant issue, particularly when reviewed in the light of the discussion provided in Chapter Seven of this thesis. The framework provides a template for ensuring that when such studies are conducted the results of the evaluation will be firmly based in the objectives of the courseware and that, if suitable instruments, are used the evaluation will provide robust and verifiable conclusions.

- The issue of reporting context of evaluations which is emphasised in the framework must be adopted in order to ensure that evaluation studies provide sufficient detail concerning the context in which the courseware developed has been used. In particular in this respect more attention needs to be paid to reconciling the claims made in the evaluation of some packages which are related to the development of high order conceptual learning and higher-order cognitive skills. The context in which the studies have been made should clearly demonstrate the manner in which these are actively fostered by CAL environments. There is a tendency currently to report on the use of computer based technologies to deliver learning using techniques which themselves are pedagogically innovative. However, in such evaluations it is very difficult to establish what the relative importance has been of the pedagogical technique, the delivery environment and the individual characteristics of the learners taking part in the activity. Rather than seek simply to demonstrate 'success' it is important for evaluations to demonstrate reasons for success and in particular demonstrate how a technologically based innovation has been central to that success.

- Again when examining the issue of context of an evaluation it is evident in significant number of reported studies on use of CAL in higher education, including this one, that issues which relate to the logistics of use and integration of CAL into teaching is still problematic. Problems of access to the courseware or failure of computer systems or networks no longer appear as prominent problems in implementation, however, a recurrent theme in the literature is the problem of motivating students to make use of laboratory based learning activities and more research is required into why students appear to be so reluctant to engage in such activities and establishing the contextual conditions which optimise the likelihood of CAL courseware being successfully implemented

- Finally such research should encompass research into attitudinal issues which manifest themselves sometimes in deep seated and quite irrational aversion to using technology. It should also examine more broadly the effect of a variety of other learner differences. This research has demonstrated that learning style was an important variable in the context of the type of courseware developed in the research to replace lectures. It is important that further work should be conducted on the implications of this variable in other contexts.

12.4 Conclusions

The aims of the research, as stated in Chapter One of the thesis were:

- to create a framework for evaluating multimedia CAL systems which specifically addresses the issue of determining the validity of claims that such systems enhance the quality of teaching and learning in higher education

- to develop multimedia CAL courseware to provide a tool for testing the validity of claims made in the literature relating to the benefits of multimedia CAL and to examine in detail (and from the learner's perspective) the mechanisms by which such systems support student learning
- to test the framework for evaluation by using it to evaluate the courseware package developed as part of the research programme and, as a consequence of following that framework, to investigate the extent to which the multimedia CAL system supports all learners equally by examining the influence of individual differences between learners on their perception of CAL systems and their performance in using it in an authentic learning environment

The first aim was achieved by a wide ranging study of the literature which allowed the development of a the new evaluation strategy to be informed by a detailed consideration of pedagogic issues (Chapters 3 and 4), individual learner differences (Chapter 5) and the institutional context in which CAL is implemented (Chapters 6 and 7). In addition, of course, it was important in fulfilling the aim to examine a range of existing methodologies for evaluation and analyse these in order to synthesise a framework which was informed by a range of different perspectives about the essential purpose of evaluation.

The second and third aims were achieved by the development and testing of the courseware described in the second part of this research. The adoption of the framework for evaluation when developing and testing the courseware ensured that the process of evaluation was methodical and well documented and did not make claims which could not be supported except on the basis of sound evidence gathered using both qualitative and quantitative approaches. In the context in which it was used in courseware development and testing within this research the framework proved to be robust and reliable as an instrument to assist the development of an evaluation strategy. Using the evaluation framework in a context in which courseware material was developed to replace parts of a 'traditional' programme of lectures involved the need to take a complex approach, with detailed profiling of students and investigating individual learner differences. A significant outcome of this was the detection circumstances in which it could be shown that CAL appeared not to provide the same benefits for all learners and that potentially learners could be disadvantaged by being constrained to use a method of learning which did not accord with their particular learning style. A number of insights into the manner in which students learn were provided during detailed observation and from feedback sessions with the students. The most important lesson from this is that it is important not to adopt a single 'academic' perspective when considering the reasons for students being willing to engage in learning and to use resources which are provided to assist their studies. A whole range of attitudinal issues must be carefully examined in order to understand what motivates students to use particular learning resources as well as investigating how well they learn when compelled to use particular resources.

Thus, the framework for evaluation which is outlined in Chapter Eight provides an important contribution to knowledge about how evaluation studies of CAL should be conducted. It does this in two ways.

Firstly the framework is based on a synthesis of many of the issues which researchers into evaluation have seen as being important factors which can affect the outcome of an evaluation. It does not rely on any one particular approach to how evaluations should be conducted, nor is it biased in terms of advocating that prominence should be given to either qualitative or quantitative measures. However it provides a basis for discriminating between a variety of possible approaches and draws attention to the significant contextual factors which will have a determining effect on which approach is most suitable given the context in which CAL courseware has been developed and implemented.

Secondly, it provides a practical tool to assist evaluators of multimedia CAL systems to ensure that the evaluation strategy they adopt is focused and that the outcome of this will be a useful and objective evaluation which is framed in terms of the objectives which were set for the courseware. If the framework is adopted in an evaluation the reported outcomes will provide a useful contribution to our understanding of the important factors which influence whether and how students learn using CAL in particular situations. Taken collectively such evaluations could then provide a basis for developing much more robust conclusions concerning the validity of using CAL in particular contexts and with particular groups of students and assist in the process of making more generalisable conclusions about CAL as a tool for learning.

Finally it should be noted that the focus of the research presented in this thesis has been the development of stand alone multimedia applications. However, the design and delivery of multimedia courseware using the World Wide Web is an activity which is now well established in higher education institutions in the United Kingdom. It is probably fair to say, however, that the implementation of a great deal of the distance learning material has not been subject to rigorous evaluation. The phenomenal growth of the Internet over the last few years is evident to anyone concerned with higher education but as with stand alone based CAL the rush to take advantage of the new technologies needs to be tempered by mature reflection on exactly what the technology needs to deliver and why. As experience grows of networked learning environments there is increasing concern that it may not be the panacea for distance learning which it was first assumed it would be. As Benyon et al. note:

> *'current tools are severely lacking in a number of important respects – particularly with respect to the design of pedagogically sound courseware' (Benyon 1997)*

Before developing new and more sophisticated tools based around the technology it is important to define clearly what the technology is required to support. To do this it is important not to frame the question in terms of what can help us deliver higher education but to consider what it is learners need and expect to get from higher education. It is to be hoped that the experience which has been gained in the past twenty years by those involved in the development and implementation of multimedia based packages will be beneficial in ensuring that the same lessons do not have to be re-learned.

In the context of the significant changes in society which are currently taking place and which are changing the manner in which work and learning are viewed it is important that, although such changes are evidently being propelled by the technology, a clear focus is maintained on the learning.

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APPENDIX 1

Appendix 1

Reeves' Dimensions of Interactive Learning Systems

Objectivism ←	EPISTEMOLOGY	→ Constructivism
Instructivist ←	PEDAGOGICAL PHILOSOPHY	→ Constructivist
Behavioural ←	UNDERLYING PHILOSOPHY	→ Cognitive
Sharply focussed ←	GOAL ORIENTATION	→ Unfocussed
Reductionist ←	INSTRUCTIONAL SEQUENCING	→ Constructivist
Abstract ←	EXPERIENTAL VALUE	→ Concrete
Teacher proof material ←	ROLE OF INSTRUCTOR	→ Egailitarian facilitator
Errorless learning ←	VALUE OF ERRORS	→ Learning from experience
Extrinsic ←	MOTIVATION	→ Intrinsic
High ←	STRUCTURE	→ Low
Non-existent ←	ACCOMMODATION OF INDIVIDUAL DIFFERENCES	→ Multi-faceted
Non-existent ←	LEARNER CONTROL	→ Unrestricted
Mathemagenic ←	USER ACTIVITY	→ Generative
Un-supported ←	CO-OPERATIVE LEARNING	→ Integral

(Reproduced from Phillips, R. The Developer's Handbook to Interactive Multimedia: a practical guide for educational applications. London: Kogan Page, 1997 p.22)

APPENDIX 2

Appendix 2
E-mail survey of CAL producers (e-mailed June/July 1999)

I am currently conducting some research into the evaluation and use of multimedia CAL materials in higher education in the United Kingdom.

Having conducted an extensive review of literature and having reviewed a number of CAL applications I would now like to collect the views of some of the developers of significant packages which have been developed within UK higher education institutions.

I would be grateful if you could complete the following brief e-mail questionnaire and return it to me as soon as possible.

Please state the title of the piece of courseware on which you are commenting:

1. **What were the aims and objectives set for development of the courseware?**

1b. **Did you employ a particular pedagogic approach to development?**

1c. **Are there any particularly novel features in the courseware?**

In particular does the courseware provide e.g. :

Simulations
Formative quizzes/self-test assessments
A concept map of to permit easy navigation
On-line glossary
Links and references to other materials (electronic or print based)

2. **Did you perform a formal evaluation of the courseware with students? (please provide details of number of students involved in testing and a brief description of the methodology if this is not covered in the literature - ref. question 5)**

3. **Is the courseware still being used? If so, roughly how many students are using the materials and how frequently?**

4. **To what do you attribute the success or failure of the courseware?**

5. **Can you provide a report or bibliographic citation of a report which details the development and evaluation of your project?**

Many thanks for your assistance
I will be happy to provide you with a copy of the summary of findings from the survey should you wish it.

Robert Newton

APPENDIX 3

Appendix 3

LIST OF COURSEWARE EXAMINED IN ORDER TO CATEGORISE COURSEWARE BY PEDAGOGICAL OBJECTIVE

Courseware Title/Producer/Bibliographic Citation to published descriptions/evaluation(s)
1. ADAPTIVES DROGEN INFORMATIONSYSTEM – ADI (University of Trier, Germany) Schoch, V. Specht, M and Weber, G. (1998) "ADI" – an empirical evaluation of a tutorial agent. World Conference Educational Multimedia and Hypermedia, Freiburg, 1998. Pp1242-1247.
2. BYZANTIUM (TLTP) – Demonstrator Disks
3. CATSKILLS (Australian Library Association)
4. CESAR - Electronic Stories (University Carlos III, Madrid) Catenazzi, N. et al. Experiences in evaluating electronic books. HyperBook and CESAR. World Cofnerence on Educational Multimedia and Hypermedia. Boston, 1996. pp. 131-136
5. Chemistry Courseware C^{3} (TLTP) Mogey, N. The sweet smell of aromatic substitions. In: Hewer, S. (1997) LTD Case Studies. Edinburgh: Heriot Watt University.
6. Choosing Books and Journals (TILT) Creanor, L. et al. (1995) A hypertext approach to information skills. Development and Evaluation. University of Glasgow: TILT
7. CLEM (University of North London) Boyle, T. et al. (1994) Taking the plunge with CLEM: The design and evaluation of a large scale CAL system. Computers in Education Vol. 22 No. 1/2. pp19-26. Boyle, T. (1997) Design for Multimedia Learning. London: Prentice-Hall.
8. CLIVE - demonstrator CD (TLTP)
9. Computer Systems (United States Military Academy) Carver et al. Enhancing student learning by incorporating learning styles into adaptive hypermedia. World Conference on Educational Multimedia and Hypermedia. Boston, 1996 pp.118-123
10. De Tudo um Puoco (Basic Portuguese Course) (TLTP)
11. Discovering Science Freake, S.(1999) Discovering Science: a distance learning course with integrated interactive media. WorldConference on Educational Multimedia and Hypermedia. Seattle, June 19th – 24th 1999. Pp.1489-1491 The Open University (1992) Discovering Science. Milton Keynes: The Open University.
12. Discovering the Nardoo (University of Wollongong,, Australia) Hedberg, J.G. and Harper, B. (1995) Exploration and investigation in information landscapes. Harper, B. and Hedberg, J.G. (1993) Investigating Lake Iluka. CD-ROM, Canberra: Interactive Multimedia Pty Ltd
13. Dosage calculations (Curtin University, Australia) Phillips, R. (1997) The Developer's Handbook to Interactive multimedia: a practical guide for educational applications. London: Kogan Page.
14. DOVE Boyle, T. (1997) Design for Multimedia Learning. London: Prentice-Hall .
15. WoPST - Word Problem Solving Looi, C-K and Tan, B.T. (1996) A computer based tutor for teaching and leaning word problem-solving. World Conference on Educational Multimedia and Hypermedia. Boston, June 17th-22nd, 1997. Pp.401-406

16. Emergence of the State of Israel (Oren: Tel Aviv University, Israel) Oren, I. New knowledge organization in the history classroom. History and Computing 3, (2) 120-131 A multiple knowledge organization environment. The case of 'The emergence of the state of Israel'. 1994 p.674
17. Fast Fracture (Engineering) (TLTP)
18. GraphIT: introduction to graphs & plots for basic statistics - downloadable version (TLTP)
19. HIS VANCOUVER 1994 p..251
20. Integrated Musicianship – 16th century (TLTP)
21. Introduction to Computer Systems (Nasri: Department of Mathematics, Beirut, Lebanon) Nasri, R. Towards a hypermedia system for teaching an introduction to computer systems. 1994 p. 671
22. Introduction to Inferential Statistics (Edith Cowan Univeristy, Australia) Herrington, J. and Oliver, R. (1999) Moving from an instuctivist to a constructivist multimedia learning environment. Proceedings of the World Conference on Educational Mutlimedia and Hypermedia. Ed-Media 99 Seattle, Washington. Pp.132-137
23. IOLIS (Law Consortium – TLTP)
24. CHINESE CHARACTERS Ki, W. et al. (1994) A knowledge based multimedia system to support the teaching and learning of Chinese characters. Procceedings of the World Conference on Educational Multimedia and Hypermedia. Vancouver June 25th - 30th, 1994 p.323-328
25. Library Search Skills – Business (TILT) Creanor, L. et al. (1995) A hypertext approach to information skills. Development and Evaluation. University of Glasgow: TILT.
26. Library Search Skills – General (TILT) Creanor, L. et al. (1995) A hypertext approach to information skills. Development and Evaluation. University of Glasgow: TILT
27. Logistics Tutor Neumann, G., Ziems, D. and Hopner, C. (1995) Use of multimedia technologies in logistics education. World Conference on Educational Multimedia and Hypermedia, Graz, Austria.. Neumann, G., Ziems, D. and Hopner, C. (1998) It's easy to be wise after the event: concepts for redesigning an educational system on logistics derived from reflecting its development and use. World Conference Educational Multimedia and Hypermedia, Freiburg, 1998. Pp.1018-1023
28. Mathwise (TLTP) Pitcher, N. Mathwise in Use. In: Hewer, S. (1997) LTDI Case Studies. Edinburgh: Heriot Watt University
29. MATTER – Materials Teaching Education Resources (TLTP)
30. MENTOR (TLTP)
31. Mitochondria (Curtin University, Australia) Phillips, R. (1997) The Developer's Handbook to Interactive multimedia: a practical guide for educational applications. London: Kogan Page.
32. FRENCH CIVILIZATION Pauly, R.M. (1996) Authoring an Interactive CD-ROM on French Civilization. World Conference on Educational Multimedia and Hypermedia. Boston, June 17th -22nd 1996 pp 569-574
33. Personal and Mobile Communication (The Robert Gordon University, Aberdeen) Newton, R. et al. Development and evaluation of WWW resources to support research methods and electronic engineering: a comparison. LTDI: Evaluation Studies. Pp.46-60
34. PharmaCALogy (TLTP) McAteer, E and Skett, P. Learning Technology in the Institute of Biomedical and Life Sciences at the University of Glasgow. In: Hewer, S. (1997) LTD Case Studies. Edinburgh: Heriot Watt University.
35. Principles of financial investment (Edith Cowan University, Australia) Stoney, S.and Oliver, R. (1999) Exploring the nature of self-regulated learning with multimedia. Proceedings of the World Conference on Educational Mutlimedia and Hypermedia. Ed- Media 99 Seattle, Washington. Pp.869-874

36. ENVIRONMENTAL INFORMATION Rosen et al. (1996) World Conference on Educational Multimedia and Hypermedia. Boston, June 17th-22nd 1996 pp.605-610
37. HyperMED: Anatomical Education Tochtermann, K. et al. (1996) World Conference on Educational Multimedia and Hypermedia. Boston, June 17th-22nd 1996 pp.667-672
38. MALL(Multimedia Assisted Language Learning) Tanaka, K (1996) World Conference on Educational Multimedia and Hypermedia. Boston, June 17th-22nd 1996 p.661-666
39. PROSA World Conference on Educational Multimedia and Hypermedia. Boston, 1996 (Demonstation Only)
40. Researching Lake Iluka (University of Wollongong, Australia) Harper, B., Hedberg, J.G. and Whelan, R. (1998) Developing skills in ecology research for undergraduate students. An interactive multimedia simulation. World Conference on Educational Multimedia and Hypermedia. Freiburg, Germany June 20th-25th pp. 476-471
41. R-Wise Carlson, P. et al. (1994) R-WISE: a computerized environment for tutoring critical literacy. World Conference on Educationa Multimedia and Hypermedia. Vancouver pp.111-116
42. Scope – Biomedical and Life Sciences (TLTP) Demonstrator versions
43. Set on Freedom Swan, K. et al. History, hypermedia and crisscrossed conceptual landscapes: designing hypermedia applications to support the development of historical thinking.Vancouver 1994 p. 535-540
44. Study Skills (TILT) Creanor, L. et al. (1995) A hypertext approach to information skills. Development and Evaluation. University of Glasgow: TILT
45. TIGER language learning packages TELL Consortium (TLTP) Demonstrator disks
46. Transit - English as a Foreign Language Foley, R. (1996) World Conference on Educational Multimedia and Hypermedia. Boston, June 17th-22nd 1996 pp. 766
47. VirCOM – Virtual Computer Boyle, T. (1997) Design for Multimedia Learning. London: Prentice-Hall.
48. WINECON (TLTP) Demonstrator version (Dowloaded)

APPENDIX 4

Appendix 4

BROWN'S CHECKLIST (from Draper et al. (1994) Observing and Measuring the Performance of Educational Technology. TILT, University of Glasgow. Appendix 1: The CAL component of a course: points for consideration)

1) Reason for Use

To teach a new course or part of a new course

To replace a course or part of a course taught at present by other methods: particularly using presentation methods (e.g. animation) not previously available
To enhance/supplement/reinforce present teaching methods

To provide a revision aid

To use student time more effectively

To improve learning efficiency

To allow existing coursework to take place effectively independently of direct staff contact (e.g. drill-based activities usually taught in small groups or even one-to-one)

To use staff time more effectively (improve staff productivity)

To improve the quality of teaching

Cost effectiveness

2) Production of Package

Number of staff and time required to author a program or package

Hardware required

Type and style of software to be used

Number of screens/time per screen

Time required by students to 'complete' package

3) Type/Style of Software

The computer-user interface

The pedagogic style

Screen features; multiple windows

Spreadsheet

Database

HyperText

Multimedia

Degree of learner control: fixed path/recommended path/user-control path

Tracking: record of student's path through package

4) Availability of CAL to student

Number and type of machines required for effective delivery of package

Compatability of package with other machines (possibility of using package on student's own machine etc.)

Estimated time required for student to complete package

Single or repeated use of package by student

Individual/pair/group use of CAL

5) Additional resources/support required

(staff and learning support required during package use)

stand-alone

lecturer

demonstrator

technician

handbook/lab manual etc.

6) CAL approach/design

Assessment: formative

Summative

Collaborative learning

Computer as aid

Computer as instructor

Databanks/data analysis

Discovery learning

(Drill &) practice

explanatory animation

games/interactive educational games

guides

intelligent tutoring

microworlds

modelling program

problem solving

productivity tools

programmed learning

revision resource

simulation

teleconferencing

tutorial

visualisation/computer graphics

Compiled from interviews, plus
Kulik, Kulik & Cohen, 1980
Kulik & Kulik (1991)
Information Technologies and Basic Learning. Centre for Educational Research (CERI). (1987)
Cunningham and Hubbold (1992)
Laurillard (1993)

7) **Assessment**

Self assessment built into package (immediate feedback to student)

Questions on subject material to be used in pre- and post- tests

Reports to be written up by students after completing package

Student's path through package and student's answers to be recorded on computer

Term/degree exams

Assessment: - formative

Summative

8) Lecturer/Tutor

Motivation of tutor
Style of introduction of students to CAL by tutor
Interaction with students
Support/training for lecturer

9) Student

Ability of student
Prior knowedge of subject
Motivation
Perception of task
Learning strategy
Prior training/experience of CAL (c.f. adaption time to computer-user interface & style of CAL)
Attitude
Age
Gender
Student interaction with system (including degree of control)
Interaction with other students
Interaction with lecturer/tutor

10) Evaluation and updating of package

Staff required to monitor and update package
Formative evaluation
Summative evaluation
Gain co-operation of students and staff for evaluation of CAL

APPENDIX 5

Appendix 5

PROTOTYPE TESTING (Lecture based material)

Formative Evaluation Report Sheet

Please indicate clearly the system which you have been using by ticking the appropriate box below:

CLASSIFICATION REQUIREMENTS LECTURE ☐

SECTION 1 – EASE OF USE AND RELEVANCE

In this section you are asked to give a response on a scale of 1 to 5 for the CAL package which you have been using.

Was it clear to you why you were using the package:

clear ☐ ☐ ☐ ☐ ☐ unclear

Did you find the package easy to use: difficult ☐ ☐ ☐ ☐ ☐ easy

List below any specific points about problems which you had with use of the package

Did you find the information appropriate for your course:

relevant ☐ ☐ ☐ ☐ ☐ irrelevant

Did you find that the information was presented in an interesting manner:

Interesting ☐ ☐ ☐ ☐ ☐ boring

Rate how useful the you found the following options which were available to you:

1 – essential

2 – very useful

3 – not very useful

4 – completely useless

	1	2	3	4
ability to go directly to specific parts of the lesson using topic buttons	☐	☐	☐	☐
ability to find occurrences of a particular word in the text (using find function)	☐	☐	☐	☐
availability of online glossary of terms (highlighted in red text)	☐	☐	☐	☐
availability of examples and further explanation	☐	☐	☐	☐
the map tool to establish the context of the topic and subtopics	☐	☐	☐	☐
short quiz section/examples to try	☐	☐	☐	☐
ability to take and save notes as you used the package	☐	☐	☐	☐

Are there any features of the CAL package which you feel could be enhanced to help you to learn better?

Comment:

APPENDIX 6

Appendix 6

PROTOTYPE TESTING

Formative Evaluation Report Sheet (Practical Materials)

Please indicate clearly the system which you have been using by ticking the appropriate box below:

INTRODUCTION TO THE DEWEY DECIMAL CLASSIFICATION SCHEME PRACTICAL ☐

SECTION 1 – EASE OF USE AND RELEVANCE

In this section you are asked to give a response on a scale of 1 to 5 for the CAL package which you have been using.

Was it clear to you why you were using the package:

clear ☐ ☐ ☐ ☐ ☐ unclear

Did you find the package easy to use: difficult ☐ ☐ ☐ ☐ ☐ easy

List below any specific points about problems which you had with use of the package

Did you find the information appropriate for your course:

relevant ☐ ☐ ☐ ☐ ☐ irrelevant

Did you find that the information was presented in an interesting manner:

Interesting ☐ ☐ ☐ ☐ ☐ boring

Rate how useful the you found the following options which were available to you:

1 – essential

2 – very useful

3 – not very useful

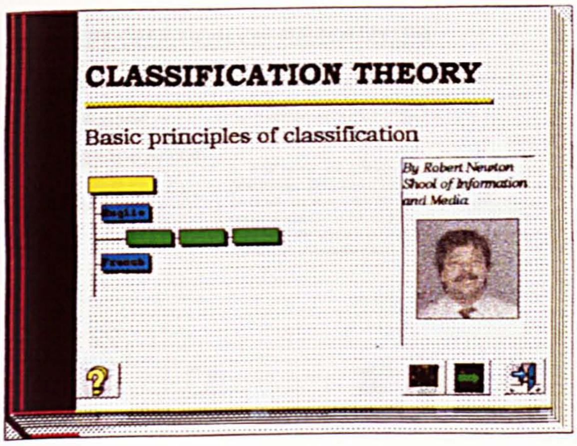
4 – completely useless

	1	2	3	4
ability to go directly to specific parts of the lesson using topic buttons	☐	☐	☐	☐
short quiz section/examples to try	☐	☐	☐	☐
availability of examples and further explanation	☐	☐	☐	☐
ability to take and save notes as you used the package	☐	☐	☐	☐

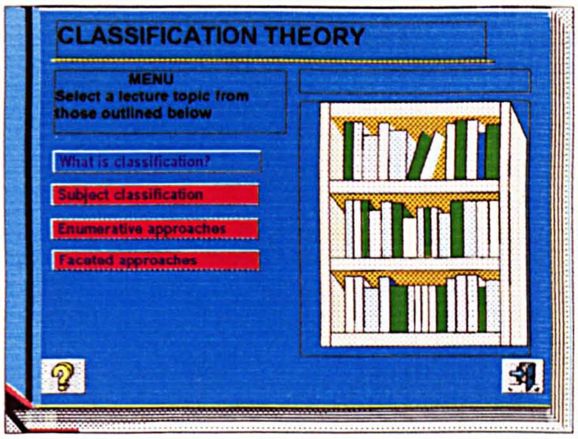
Are there any features of the CAL package which you feel could be enhanced to help you to learn better?

Comment:

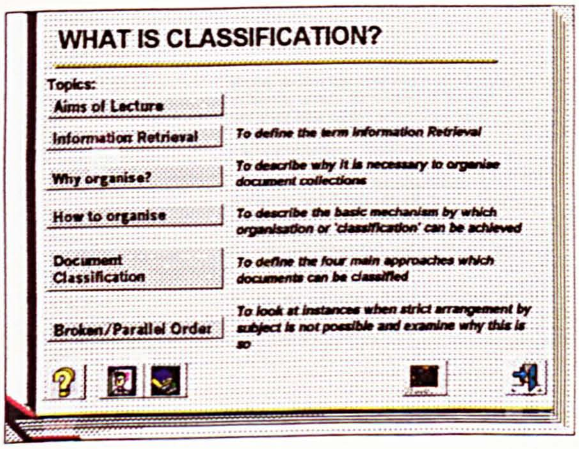
APPENDIX 7



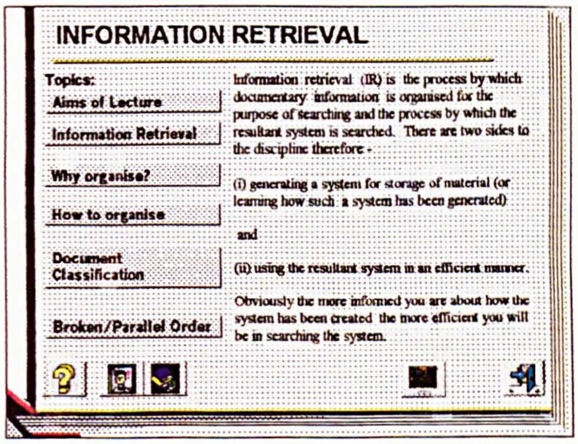
CLASSIFICATION THEORY
Basic principles of classification
By Robert Newton
Shool of Information
and Media



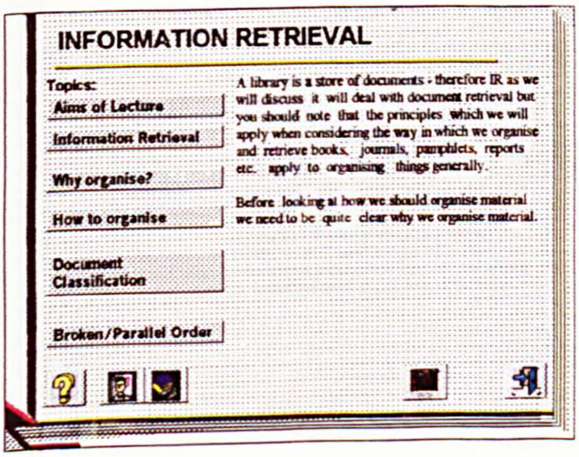
CLASSIFICATION THEORY
MENU
Select a lecture topic from
those outlined below
What is classification?
Subject classification
Enumerative approaches
Faceted approaches



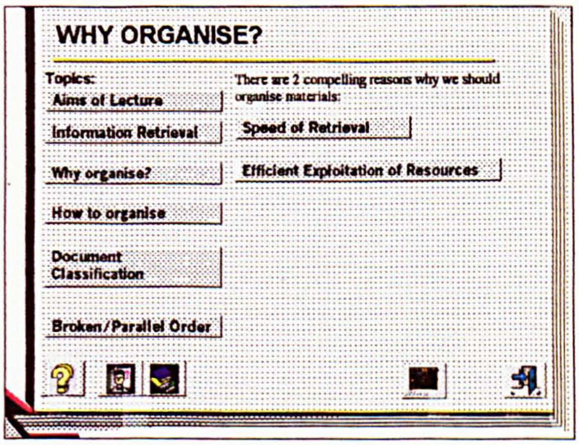
WHAT IS CLASSIFICATION?
Topics:
Aims of Lecture
Information Retrieval
To define the term Information Retrieval
Why organise?
To describe why it is necessary to organise document collections
How to organise
To describe the basic mechanism by which organisation or 'classification' can be achieved
Document Classification
To define the four main approaches which documents can be classified
Broken/Parallel Order
To look at instances when strict arrangement by subject is not possible and examine why this is so



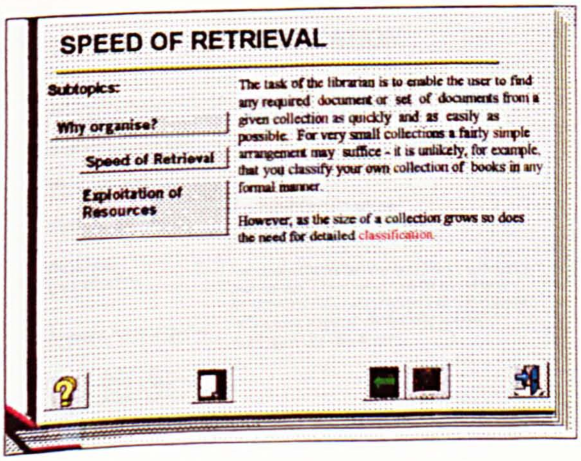
INFORMATION RETRIEVAL
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
Information retrieval (IR) is the process by which documentary information is organised for the purpose of searching and the process by which the resultant system is searched. There are two sides to the discipline therefore -
(i) generating a system for storage of material (or learning how such a system has been generated)
and
(ii) using the resultant system in an efficient manner.
Obviously the more informed you are about how the system has been created the more efficient you will be in searching the system.



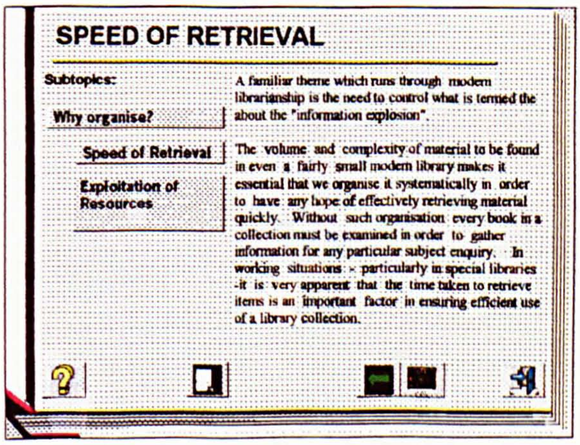
INFORMATION RETRIEVAL
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
A library is a store of documents - therefore IR as we will discuss it will deal with document retrieval but you should note that the principles which we will apply when considering the way in which we organise and retrieve books, journals, pamphlets, reports etc. apply to organising things generally.
Before looking at how we should organise material we need to be quite clear why we organise material.



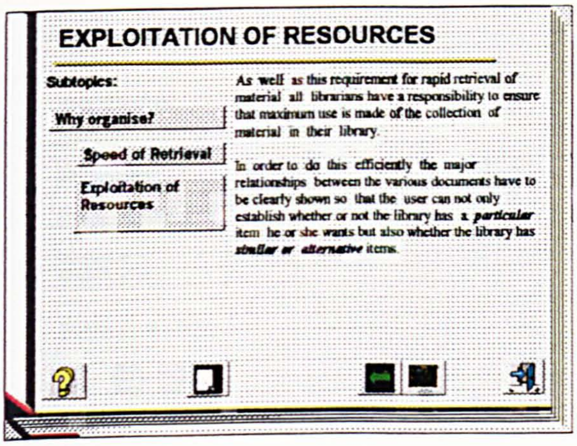
WHY ORGANISE?
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
There are 2 compelling reasons why we should organise materials:
Speed of Retrieval
Efficient Exploitation of Resources

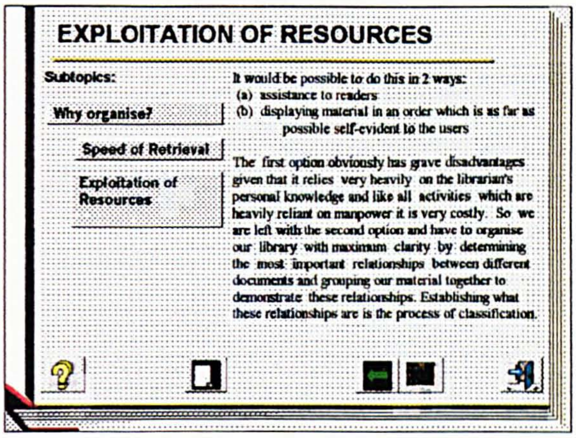


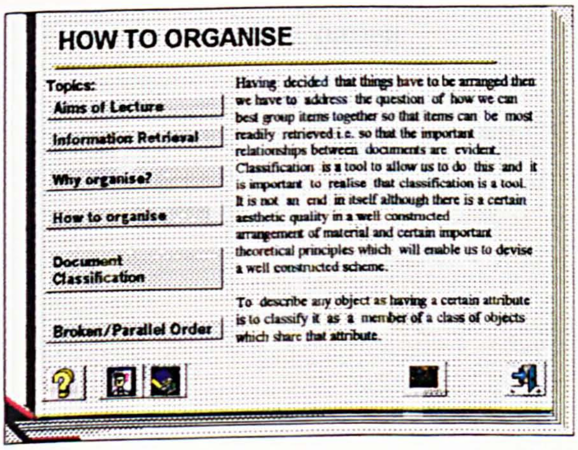
SPEED OF RETRIEVAL
Subtopics:
Why organise?
Speed of Retrieval
Exploitation of Resources
The task of the librarian is to enable the user to find any required document or set of documents from a given collection as quickly and as easily as possible. For very small collections a fairly simple arrangement may suffice - it is unlikely, for example, that you classify your own collection of books in any formal manner.
However, as the size of a collection grows so does the need for detailed classification.

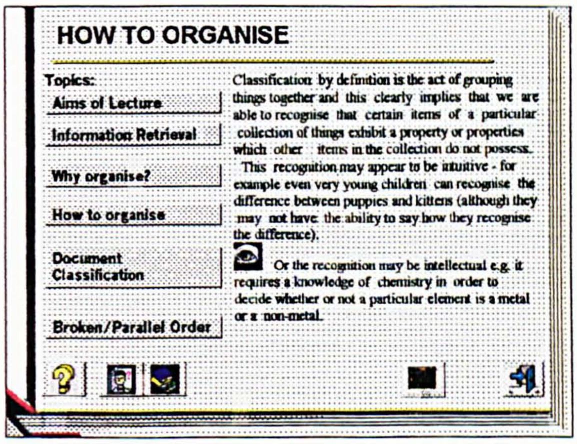


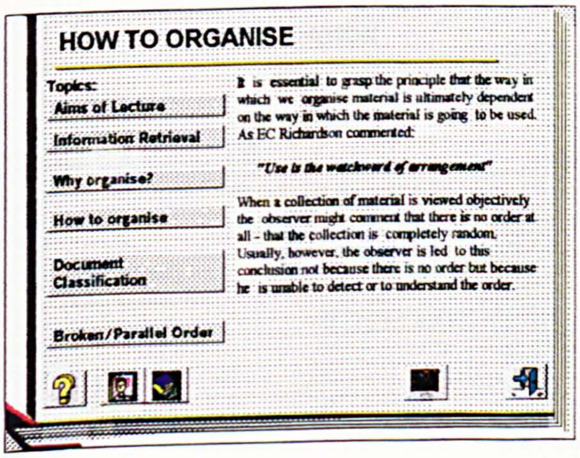
SPEED OF RETRIEVAL
Subtopics:
Why organise?
Speed of Retrieval
Exploitation of Resources
A familiar theme which runs through modern librarianship is the need to control what is termed the about the "information explosion".
The volume and complexity of material to be found in even a fairly small modern library makes it essential that we organise it systematically in order to have any hope of effectively retrieving material quickly. Without such organisation every book in a collection must be examined in order to gather information for any particular subject enquiry. In working situations - particularly in special libraries - it is very apparent that the time taken to retrieve items is an important factor in ensuring efficient use of a library collection.

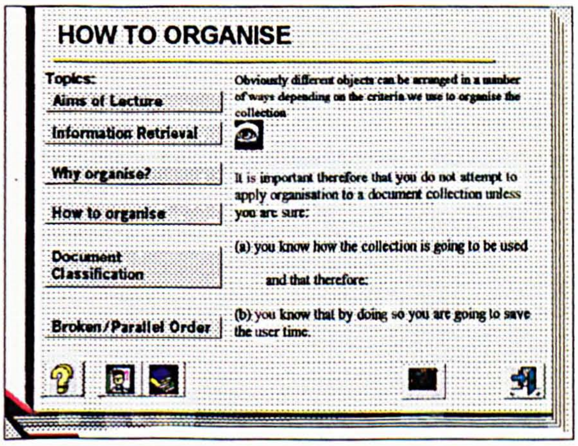

EXPLOITATION OF RESOURCES
Subtopics:
Why organise?
Speed of Retrieval
Exploitation of Resources
As well as this requirement for rapid retrieval of material all librarians have a responsibility to ensure that maximum use is made of the collection of material in their library.
In order to do this efficiently the major relationships between the various documents have to be clearly shown so that the user can not only establish whether or not the library has a particular item he or she wants but also whether the library has similar or alternative items.

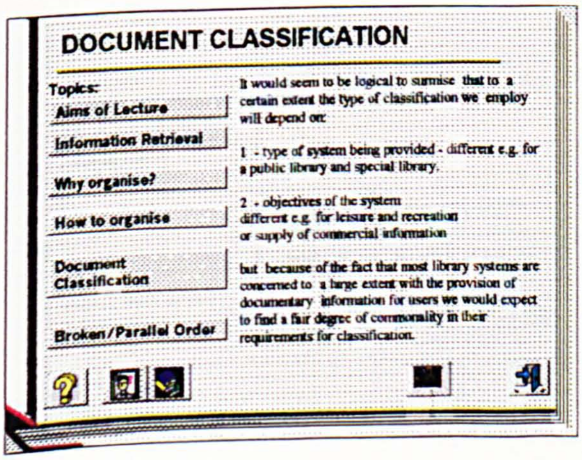

EXPLOITATION OF RESOURCES
Subtopics:
Why organise?
Speed of Retrieval
Exploitation of Resources
It would be possible to do this in 2 ways:
(a) assistance to readers
(b) displaying material in an order which is as far as possible self-evident to the users
The first option obviously has grave disadvantages given that it relies very heavily on the librarian's personal knowledge and like all activities which are heavily reliant on manpower it is very costly. So we are left with the second option and have to organise our library with maximum clarity by determining the most important relationships between different documents and grouping our material together to demonstrate these relationships. Establishing what these relationships are is the process of classification.

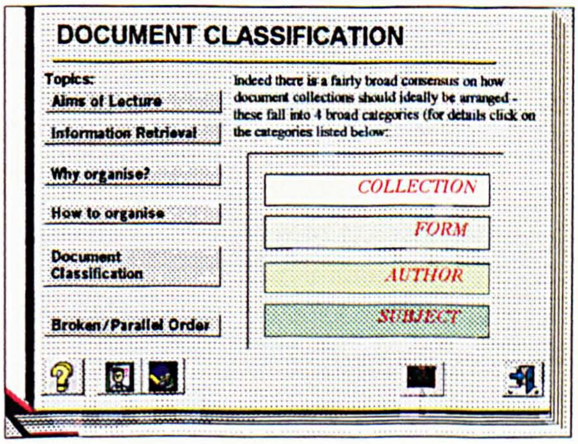

HOW TO ORGANISE
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
Having decided that things have to be arranged then we have to address the question of how we can best group items together so that items can be most readily retrieved i.e. so that the important relationships between documents are evident. Classification is a tool to allow us to do this and it is important to realise that classification is a tool. It is not an end in itself although there is a certain aesthetic quality in a well constructed arrangement of material and certain important theoretical principles which will enable us to devise a well constructed scheme.
To describe any object as having a certain attribute is to classify it as a member of a class of objects which share that attribute.

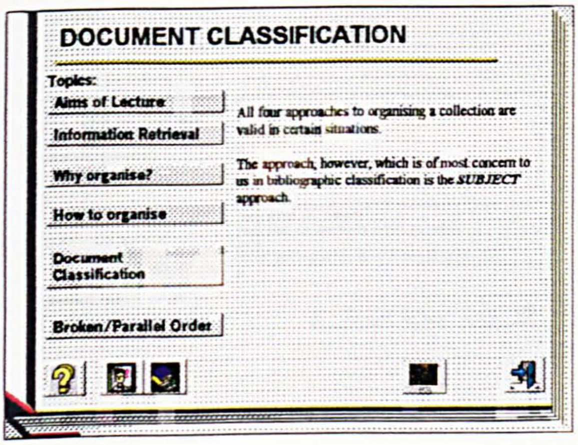

HOW TO ORGANISE
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
Classification by definition is the act of grouping things together and this clearly implies that we are able to recognise that certain items of a particular collection of things exhibit a property or properties which other items in the collection do not possess. This recognition may appear to be intuitive - for example even very young children can recognise the difference between puppies and kittens (although they may not have the ability to say how they recognise the difference).
Or the recognition may be intellectual e.g. it requires a knowledge of chemistry in order to decide whether or not a particular element is a metal or a non-metal.

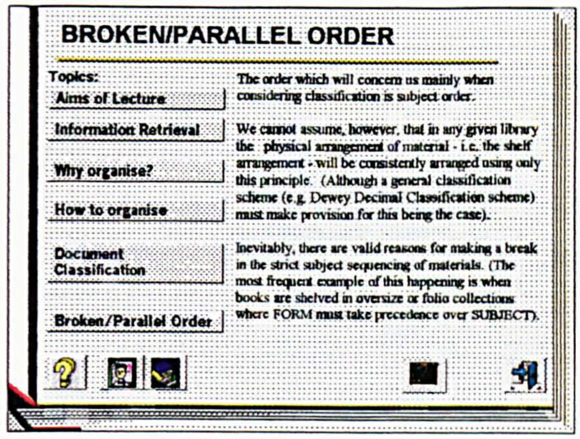

HOW TO ORGANISE
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
It is essential to grasp the principle that the way in which we organise material is ultimately dependent on the way in which the material is going to be used. As EC Richardson commented:
"Use is the watchword of arrangement"
When a collection of material is viewed objectively the observer might comment that there is no order at all - that the collection is completely random. Usually, however, the observer is led to this conclusion not because there is no order but because he is unable to detect or to understand the order.

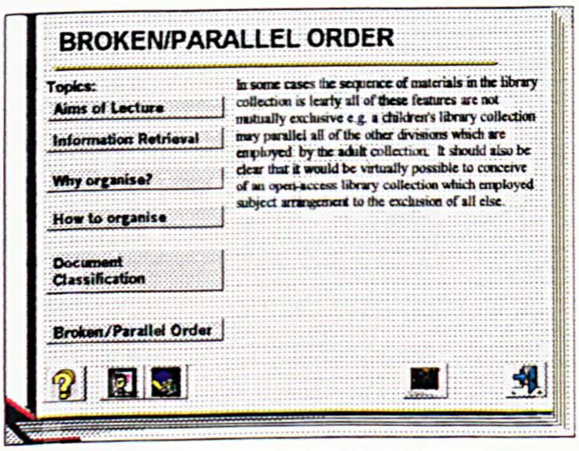

HOW TO ORGANISE
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
Obviously different objects can be arranged in a number of ways depending on the criteria we use to organise the collection.
It is important therefore that you do not attempt to apply organisation to a document collection unless you are sure:
(a) you know how the collection is going to be used
and that therefore:
(b) you know that by doing so you are going to save the user time.

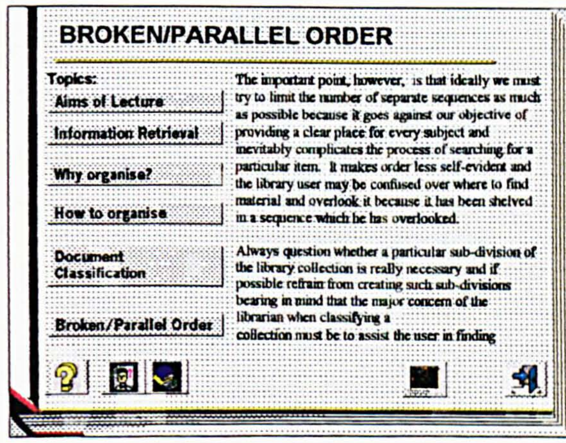

DOCUMENT CLASSIFICATION
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
It would seem to be logical to surmise that to a certain extent the type of classification we employ will depend on:
1 - type of system being provided - different e.g. for a public library and special library.
2 - objectives of the system different e.g. for leisure and recreation or supply of commercial information
but because of the fact that most library systems are concerned to a large extent with the provision of documentary information for users we would expect to find a fair degree of commonality in their requirements for classification.

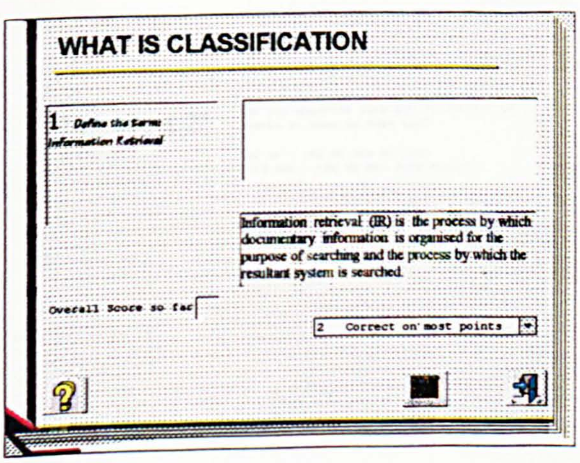

DOCUMENT CLASSIFICATION
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
Indeed there is a fairly broad consensus on how document collections should ideally be arranged - these fall into 4 broad categories (for details click on the categories listed below:
COLLECTION
FORM
AUTHOR
SUBJECT

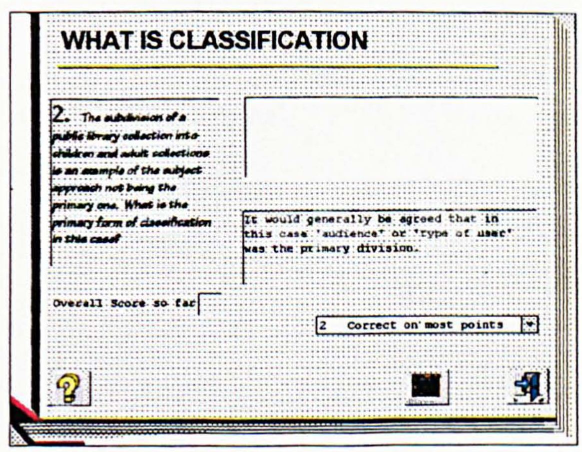

DOCUMENT CLASSIFICATION
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
All four approaches to organising a collection are valid in certain situations.
The approach, however, which is of most concern to us in bibliographic classification is the SUBJECT approach.

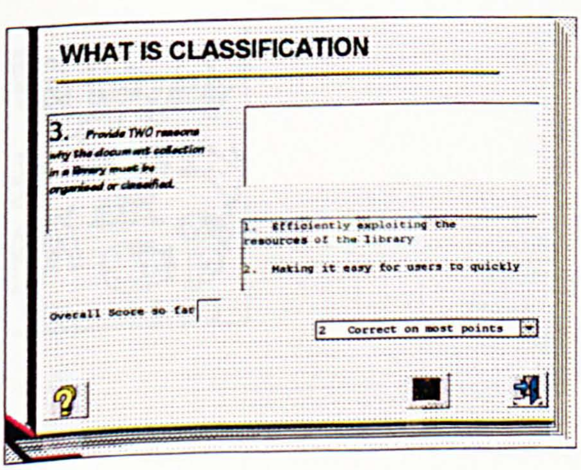

BROKEN/PARALLEL ORDER
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
The order which will concern us mainly when considering classification is subject order.
We cannot assume, however, that in any given library the physical arrangement of material - i.e. the shelf arrangement - will be consistently arranged using only this principle. (Although a general classification scheme (e.g. Dewey Decimal Classification scheme) must make provision for this being the case).
Inevitably, there are valid reasons for making a break in the strict subject sequencing of materials. (The most frequent example of this happening is when books are shelved in oversize or folio collections where FORM must take precedence over SUBJECT).

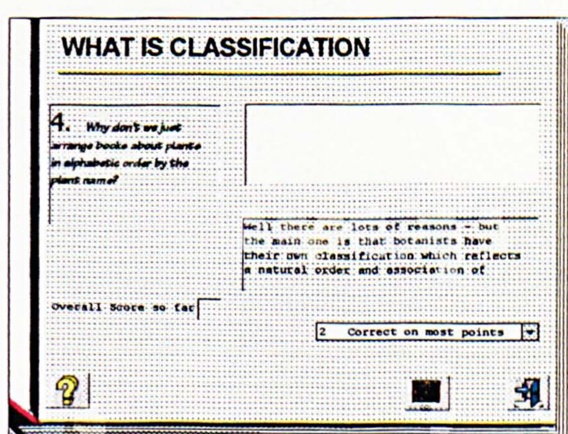

BROKEN/PARALLEL ORDER
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
In some cases the sequence of materials in the library collection is clearly all of these features are not mutually exclusive e.g. a children's library collection may parallel all of the other divisions which are employed by the adult collection. It should also be clear that it would be virtually possible to conceive of an open-access library collection which employed subject arrangement to the exclusion of all else.

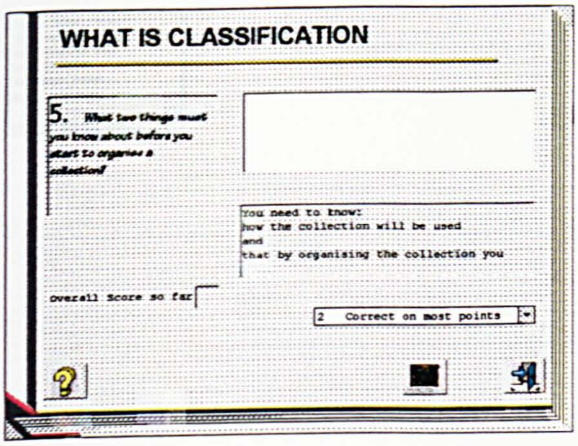

BROKEN/PARALLEL ORDER
Topics:
Aims of Lecture
Information Retrieval
Why organise?
How to organise
Document Classification
Broken/Parallel Order
The important point, however, is that ideally we must try to limit the number of separate sequences as much as possible because it goes against our objective of providing a clear place for every subject and inevitably complicates the process of searching for a particular item. It makes order less self-evident and the library user may be confused over where to find material and overlook it because it has been shelved in a sequence which he has overlooked.
Always question whether a particular sub-division of the library collection is really necessary and if possible refrain from creating such sub-divisions bearing in mind that the major concern of the librarian when classifying a collection must be to assist the user in finding

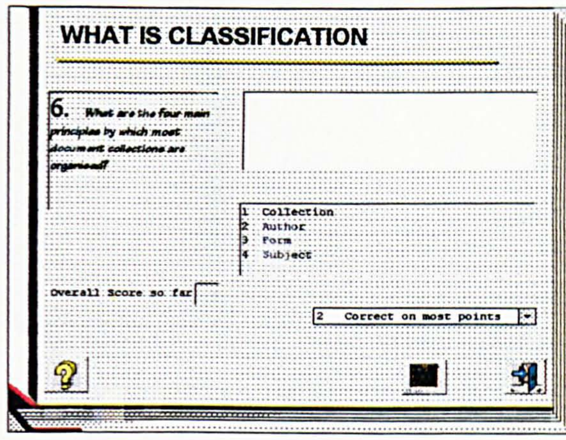

WHAT IS CLASSIFICATION
1. Define the term: Information Retrieval
Information retrieval (IR) is the process by which documentary information is organised for the purpose of searching and the process by which the resultant system is searched.
Overall Score so far
2 Correct on most points

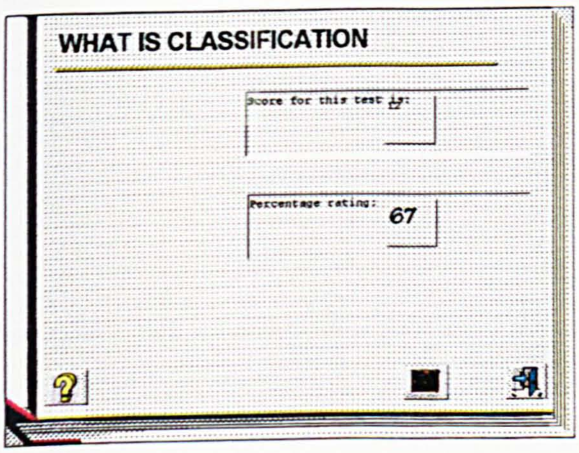

WHAT IS CLASSIFICATION
2. The subdivision of a public library collection into children and adult collections is an example of the subject approach not being the primary one. What is the primary form of classification in this case?
It would generally be agreed that in this case 'audience' or 'type of user' was the primary division.
Overall Score so far
2 Correct on most points

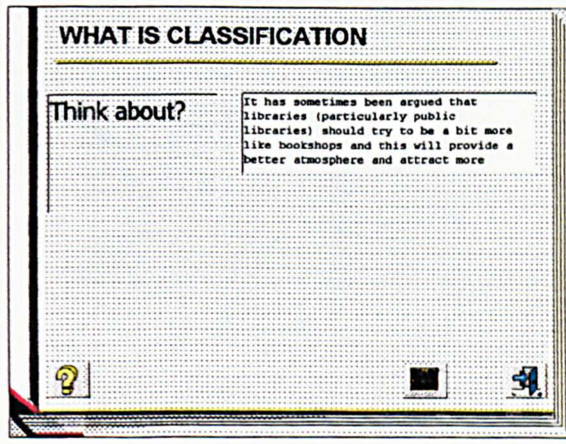

WHAT IS CLASSIFICATION
3. Provide TWO reasons why the document collection in a library must be organised or classified.
1. Efficiently exploiting the resources of the library
2. Making it easy for users to quickly
Overall Score so far
2 Correct on most points

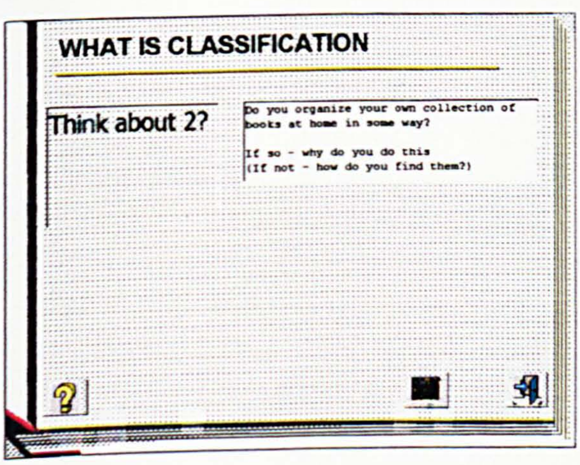

WHAT IS CLASSIFICATION
4. Why don't we just arrange books about plants in alphabetic order by the plant name?
Well there are lots of reasons - but the main one is that botanists have their own classification which reflects a natural order and association of
Overall Score so far
2 Correct on most points

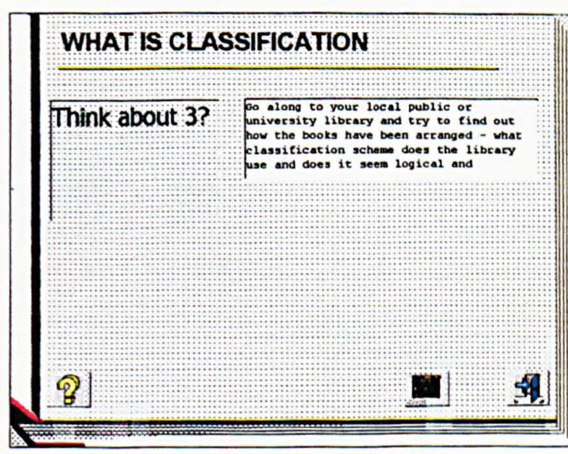

WHAT IS CLASSIFICATION
5. What two things must you know about before you start to organise a collection?
You need to know:
how the collection will be used
and
that by organising the collection you
Overall Score so far
2 Correct on most points

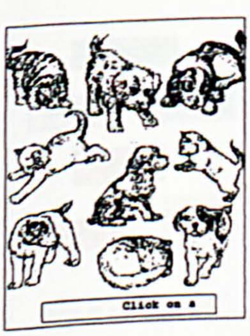

WHAT IS CLASSIFICATION
6. What are the four main principles by which most document collections are organised?
1 Collection
2 Author
3 Form
4 Subject
Overall Score so far
2 Correct on most points


WHAT IS CLASSIFICATION
Score for this test is:
Percentage rating:
67

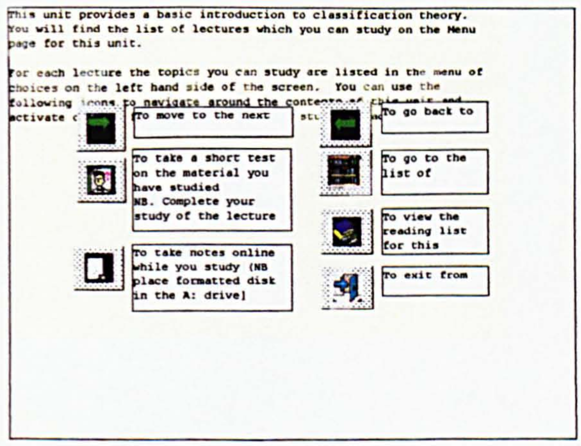

WHAT IS CLASSIFICATION
Think about?
It has sometimes been argued that libraries (particularly public libraries) should try to be a bit more like bookshops and this will provide a better atmosphere and attract more

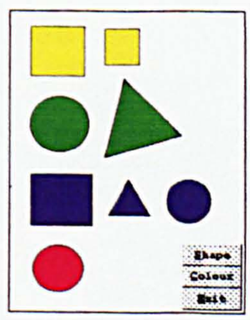

WHAT IS CLASSIFICATION
Think about 2?
Do you organize your own collection of books at home in some way?
If so - why do you do this
(If not - how do you find them?)

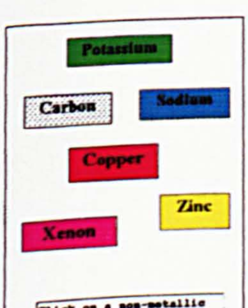

WHAT IS CLASSIFICATION
Think about 3?
Go along to your local public or university library and try to find out how the books have been arranged - what classification scheme does the library use and does it seem logical and


Click on a

Langridge, D.W.
Subject analysis:
principles and
procedures.
London: 1989
p.1







BROKEN/PARALLEL ORDER:

Broken order strictly interpreted means that a particular section of material has been shelved out of the main sequence en bloc and removed to an alternative location e.g. when setting up a departmental library the entire sequence dealing with a particular subject may be physically removed. Parallel order refers

APPENDIX 8

Summaries

First Summary*

The Ten Main Classes

000	**Generalities**
100	**Philosophy & psychology**
200	**Religion**
300	**Social sciences**
400	**Language**
500	**Natural sciences & mathematics**
600	**Technology (Applied sciences)**
700	**The arts**
800	**Literature & rhetoric**
900	**Geography & history**

*Consult schedules for complete and exact headings

Second Summary*
The Hundred Divisions

000 Generalities
- 010 Bibliography
- 020 Library & information sciences
- 030 General encyclopedic works
- 040
- 050 General serials & their indexes
- 060 General organizations & museology
- 070 News media, journalism, publishing
- 080 General collections
- 090 Manuscripts & rare books

100 Philosophy & psychology
- 110 Metaphysics
- 120 Epistemology, causation, humankind
- 130 Paranormal phenomena
- 140 Specific philosophical schools
- 150 Psychology
- 160 Logic
- 170 Ethics (Moral philosophy)
- 180 Ancient, medieval, Oriental philosophy
- 190 Modern Western philosophy

200 Religion
- 210 Natural theology
- 220 Bible
- 230 Christian theology
- 240 Christian moral & devotional theology
- 250 Christian orders & local church
- 260 Christian social theology
- 270 Christian church history
- 280 Christian denominations & sects
- 290 Other & comparative religions

300 Social sciences
- 310 General statistics
- 320 Political science
- 330 Economics
- 340 Law
- 350 Public administration
- 360 Social services; association
- 370 Education
- 380 Commerce, communications, transport
- 390 Customs, etiquette, folklore

400 Language
- 410 Linguistics
- 420 English & Old English
- 430 Germanic languages German
- 440 Romance languages French
- 450 Italian, Romanian, Rhaeto-Romanic
- 460 Spanish & Portuguese languages
- 470 Italic languages Latin
- 480 Hellenic languages Classical Greek
- 490 Other languages

500 Natural sciences & mathematics
- 510 Mathematics
- 520 Astronomy & allied sciences
- 530 Physics
- 540 Chemistry & allied sciences
- 550 Earth sciences
- 560 Paleontology Paleozoology
- 570 Life sciences
- 580 Botanical sciences
- 590 Zoological sciences

600 Technology (Applied sciences)
- 610 Medical sciences Medicine
- 620 Engineering & allied operations
- 630 Agriculture
- 640 Home economics & family living
- 650 Management & auxiliary services
- 660 Chemical engineering
- 670 Manufacturing
- 680 Manufacture for specific uses
- 690 Buildings

700 The arts
- 710 Civic & landscape art
- 720 Architecture
- 730 Plastic arts Sculpture
- 740 Drawing & decorative arts
- 750 Painting & paintings
- 760 Graphic arts Printmaking & prints
- 770 Photography & photographs
- 780 Music
- 790 Recreational & performing arts

800 Literature & rhetoric
- 810 American literature in English
- 820 English & Old English literatures
- 830 Literatures of Germanic languages
- 840 Literatures of Romance languages
- 850 Italian, Romanian, Rhaeto-Romanic
- 860 Spanish & Portuguese literatures
- 870 Italic literatures Latin
- 880 Hellenic literatures Classical Greek
- 890 Literatures of other languages

900 Geography & history
- 910 Geography & travel
- 920 Biography, genealogy, insignia
- 930 History of ancient world
- 940 General history of Europe
- 950 General history of Asia Far East
- 960 General history of Africa
- 970 General history of North America
- 980 General history of South America
- 990 General history of other areas

*Consult schedules for complete and exact headings

APPENDIX 9

APPENDIX 9 - SAMPLE PORTION OF A TRACKING LOG FROM EARLY USE OF THE PROTOTYPE

```
Title Page,                    18:40:51 PM
Menu,                          18:40:53 PM
Lecture2,                      18:42:53 PM
Lecture,                       18:43:07 PM
Notation,                      18:44:02 PM
Index,                         18:45:04 PM
Menu,                          18:46:08 PM
Title Page,                    18:47:32 PM
Menu,                          18:47:34 PM
Lecture1,                      18:53:37 PM
Lecture1,                      18:53:48 PM
The Major Schemes,             19:00:50 PM
Literary Warrant,              19:11:52 PM
Menu,                          19:11:55 PM
Example                        19:15:55 PM
```

...

APPENDIX 10

APPENDIX 10
PRACTICAL TEST OF DEWEY MAIN CLASS ALLOCATION

Provide the Dewey Decimal Classification main class division for each of the following topics:

1. **Law**
2. **Languages**
3. **Flags**
4. **Rugby**
5. **Geography**
6. **Biology**
7. **Chemistry**
8. **Music**
9. **Mathematics**
10. **Economics**
11. **Judaism**
12. **French**
13. **Prayer**
14. **Psychology**
15. **Travel**
16. **Card games**
17. **Athletics**
18. **Politics**
19. **Medicine**
20. **Physics**
21. **English Literature**
22. **Horse Racing**
23. **Poetry**
24. **Italian Grammar**
25. **Ice skating**

APPENDIX 11

APPENDIX 11 PRACTICAL TEST OF DEWEY MAIN CLASS ALLOCATION

Provide the Dewey Decimal Classification main class division for each of the following topics:

1. **Christianity**
2. **Philology**
3. **Travel**
4. **Tennis**
5. **Geology**
6. **Botany**
7. **Education**
8. **Opera**
9. **Algebra**
10. **Sociology**
11. **African History**
12. **Latin**
13. **Meditation**
14. **Paranormal phenomena**
15. **Horse Racing**
16. **Architecture**
17. **Sport**
18. **Commerce**
19. **Surgery**
20. **Pathology**
21. **French Literature**
22. **Physiology**
23. **Plays**
24. **English Grammar**
25. **Chess**

APPENDIX 12

APPENDIX 12 Anecdotal Record Form (From Reeves, 1994)

Evaluation data does not have to be reported as "cold hard statistics." Often you will want to tell the "human story" involved in your development or implementation project. One way of capturing those important stories and critical incidents that provide the human story is the "Anecdotal Record Form." Participants in an interactive multimedia design project can use this instrument to describe a noteworthy event and to offer their own interpretation of its relevance. It is very important to try to complete an Anecdotal Record Form as soon as possible after a critical event has occurred so as not to forget critical information. It is equally important to separate your description of the incident from your interpretation of it!

Instructions:

1. As a participant in an interactive multimedia design project, you will observe incidents or listen to reports of incidents which relate to the development and impact of the program. It is important that this kind of anecdotal information be systematically recorded so that the story of the development and outcomes of this project can be understood. Therefore, you should complete an Anecdotal Record Form whenever you witness or hear of a significant incident relating to the progress and accomplishments of project. An anecdotal record is a verbal account which exhibits these characteristics:

a. Each anecdote should be limited to a single incident.
b. It should contain a factual, non-inferential description of the observed or reported incident. (For example, "The trainees said 'I've never enjoyed using a computer before.' " instead of "The trainee expressed satisfaction with the training system.")
c. It should include a description of the situation in which the incident occurs so that the meaning of the behavior can be understood.
d. It should be written as soon as possible after witnessing or hearing about the incident so that all important details can be included.
e. It should include a separate section describing your interpretation of or feelings about the anecdote. Your personal evaluation is important because your judgments about the project are valued highly.

2. A copy of a blank Anecdotal Record Form as well as a sample completed form appears below.

BLANK ANECDOTAL RECORD FORM

DATE: ________ PLACE: ______

NAME OF OBSERVER: ________

Description of the incident:

Interpretation:

APPENDIX 13

APPENDIX 13 -

QUESTIONNAIRE ON CAL PACKAGE AS A SUBSTITUTE TO LECTURE

SECTION 1 - YOUR USE OF THE PACKAGE	PLEASE INDICATE WITH BY TICKING THE APPROPRIATE BOX YOUR RESPONSE TO EACH QUESTION						
Was it clear to you why you were using the package?	Clear						Unclear
Did you find the package easy to use?	Easy						Difficult
Did you find the information appropriate for your course	Relevant						Irrelevant
Did you find that the information was presented in an interesting manner	Interesting						Boring
Specific Problems Notes							

Question	PLEASE INDICATE WITH BY TICKING THE APPROPRIATE BOX YOUR RESPONSE TO EACH QUESTION					
Do you feel the CAL package has covered the aims and objectives for the 'lecture' ?	Yes		Partly		No	
Reasons provided for response to Q 1.						
Do you feel you can learn more or less easily using the CAL package than during a lecture session?	Less		Same		More	
How would you rate your overall attitude to learning using CAL packages?	+ve		Neutral		-ve	
Would you be happy to have your entire module delivered using CAL materials rather than attend formal lectures ?	Yes		Unsure		No	
Would you like to see CAL packages made available for other parts of your course?	Yes		Unsure		No	
Give an example or examples of what you liked best about learning while using the CAL package						
Give an example or examples of what you liked least about learning while using the CAL package						
Other Comments						

APPENDIX 14

APPENDIX 14

QUESTIONNAIRE ON CAL PACKAGE AS A SUBSTITUTE TO PRACTICAL CLASS

Question Posed	**PLEASE INDICATE YOUR RESPONSE BY TICKING THE APPROPRIATE BOX**						
1. Was it clear to you why you were using the package?	Clear						Unclear
2. Did you find the package easy to use?	Easy						Difficult
3. Did you find the information appropriate for your course	Relevant						Irrelevant
4. Did you find that the information was presented in an interesting manner	Interesting						Boring
5. Specific Problems Notes							

Question	**PLEASE INDICATE YOUR RESPONSE BY TICKING THE APPROPRIATE BOX**					
Has the material presented in the package increased your understanding of practical procedures for bibliographic classification?	Yes		Partly		No	
Reasons provided for response to Q 1.						
Do you feel you learn more or less easily using the CAL package than during normal practical sessions?	Less		Same		More	
How would you rate your overall attitude to learning using CAL packages?	+ve		Neutral		-ve	
Would you like to see CAL packages made available for other parts of your course?	Yes		Unsure		No	
Give an example or examples of what you liked best about learning while using the CAL package						
Give an example or examples of what you liked least about learning while using the CAL package						
Other Comments						

APPENDIX 15

STUDENT PERSONAL AND STUDY PROFILE

Name: **Course:** **Postgraduate Information and Library Studies**

Please provide answers to the following questions

1. **How do you rate your motivation to do well on this course:**

Low 1 2 3 4 5 High

Expand briefly on what motivates you to do well

I WOULD LIKE TO FIND A PROFESSIONAL POSITION IN INFORMATION WORK WHICH BUILDS ON MY PREVIOUS EXPERIENCE

2. **In what subject did you take your undergraduate degree?:** ENGLISH LITERATURE LANGUAGE

2b **What class of degree were you awarded:** 1ST

2c **How well do you feel the degree you were awarded in your previous course reflects your academic ability?:**

Poorly 1 2 3 4 5 Accurately

3 **In which of the following areas do you feel you will be particularly strong or weak:**

Time Management	Weak	1	2	3	4	5	Strong
Academic Ability	Weak	1	2	3	4	5	Strong
Good study technique	Weak	1	2	3	4	5	Strong
Ability to work independently	Weak	1	2	3	4	5	Strong
Ability to work in groups	Weak	1	2	3	4	5	Strong
Previous subject related experience	Weak	1	2	3	4	5	Strong
Previous vocational experience	Weak	1	2	3	4	5	Strong
Ability to find and use information	Weak	1	2	3	4	5	Strong
Motivation to do well	Weak	1	2	3	4	5	Strong

Please turn over

4. How important do you feel it is to get a good academic result in your diploma/Masters degree to positively influence your prospects for finding suitable employment?

Low 1 2 3 4 5 High

5. Do you have any particular personal circumstances/problems which you feel will have an impact on your studies. Please list?

YES - FINANCIAL CONSTRAINTS

6. Do you wish to arrange a time to see the Course Leader for a personal interview?

Yes / No.

If yes, please see me after the introductory session to arrange a suitable time tomorrow morning.

Robert Newton
September 1998

APPENDIX 16

APPENDIX 16

PRIOR EXPERIENCE/KNOWLEDGE OF BIBLIOGRAPHIC CLASSIFICATION

Please answer the following questions. Note if you feel you cannot answer a question do NOT WORRY. This test is to assess how much you already know about the topic we are about to study.

1. Can you name one major bibliographic classification scheme?

2. What is meant by the term notation?

3. What is the function of an author mark?

4. What is a form class?

5. What is distinctive about a faceted classification scheme?

Thank you for taking time to complete this short test. N.B. this test completely anonymous and is designed to look overall at the background knowledge of the class.

APPENDIX 17

School of Information & Media

Basic Information Technology Applications

This short questionnaire is designed to establish your current level of IT skills and experience. The results will be used to tailor the Basic IT course to best suit your needs.

Please complete the questionnaire as fully as possible.

Name : ______________________________

Section 1 : Previous computer experience

1.1 Which type(s) of computer system have you used?

none	❑		
PC (DOS)	❑	Apple Macintosh	❑
PC (Windows 3.x)	❑	UNIX	❑
PC (Windows 95)	❑	Windows NT	❑

other (please state) ______________________________

1.2 How long have you been using computers for?

- < 3 months ❑
- 3 - 6 months ❑
- 6 months -1 year ❑
- > 1 year ❑

1.3 How would you describe your present level of computer experience?

- Complete novice ❑
- Inexperienced ❑
- Familiar ❑
- Experienced ❑
- Very experienced ❑

Section 2 : Software

2.1 Have you used Microsoft *Windows* before?

- Yes ❑
- No ❑

2.2 Have you used a word-processor before?

- No ❑
- Yes ❑

Which one?

- *Word for Windows* ❑

other (please state) ______________________________

2.3 Have you used a spreadsheet before?

No ☐
Yes ☐
Which one?
Excel ☐
other (please state) ______________________

2.4 Have you used presentation software before?

No ☐
Yes ☐
Which one?
PowerPoint ☐
other (please state) ______________________

2.5 Have you used database software before?

No ☐
Yes ☐
Which one?
Access ☐
other (please state) ______________________

Section 3 : Electronic mail and the Internet

3.1 Have you used electronic mail (email) before?

Yes ☐
No ☐

3.2 Have you used any of the following Internet tools?

	Yes	No
Telnet	☐	☐
FTP	☐	☐
Gopher	☐	☐
World Wide Web	☐	☐

Please return the completed questionnaire to your *Course Leader* at the School of Information and Media, Hilton.

Thank you for your time

APPENDIX 18

APPENDIX 18

COMPUTER ATTITUDE QUESTIONNAIRE

PLEASE READ EACH STATEMENT BELOW AND THEN INDICATE BY TICKING THE APPROPRIATE BOX THE NUMBER WHICH SHOWS HOW YOU FEEL

SD - STRONGLY DISAGREE
D - DISAGREE
U - UNDECIDED
A - AGREE
SA - STRONGLY AGREE

1. I enjoy doing things on a computer	SD	D	U	A	SA
2. I am tired of using computers					
3. I will be able to get a good job if I learn about computers					
4. I concentrate on a computer when I use one					
5. I enjoy computer games very much					
6. I would work harder if I could use computers more often					
7. I know that computers give me opportunities to learn new things					
8. I can learn many things when I use a computer					
9. I enjoy lessons on a computer					
10. I think if more use is made of computers I will enjoy my studies more					
11. I believe it is important for me to learn to use the computer					
12. I feel comfortable working with computers					
13. I get a sinking feeling when I think of using computers					
14. Computers make the job longer for me					
15. Working with a computer makes me nervous					
16. Using a computer is frustrating					
17. I work with computers as little as possible					
18. Computers are difficult to use					
19. Computers do not scare me at all					
20. I can learn more from books than from a computer					

APPENDIX 19

WORD MATRIX

	1	2	3	4	5	
a.	4 objective	2 perfectionist	1 solid	3 practical	1 careful with detail	a. 11
b.	1 evaluative	3 research	2 quality	1 rational	2 ideas	b. 9
c.	2 sensitive	4 colorful	4 non judgmental	2 lively	4 aware	c. 16
d.	3 intuitive	1 risk-taker	3 insightful	4 perceptive	3 creative	d 14

	6	7	8	9	10	
a.	4 thorough	1 realistic	2 ordered	2 persistent	2 product oriented	11
b.	3 logical	3 referential	1 proof	1 analytical	1 judge	9
c.	2 spontaneous	4 empathy	3 attuned	4 aesthetic	4 person oriented	17
d.	1 trouble shooter	2 innovative	4 multi-solutions	3 experimenting	3 practical dreamer	13

Total of above	22	18	33	27
	CS	AS	AR	CE

DIRECTIONS

Before starting with the word matrix on the next page, carefully read all seven of the following directions and suggestions:

1. **Reference Point.** You must assess the relative value of the words in each group using your SELF as a reference point; that is, who you are deep down. NOT who you are at home, at work, at school or who you would like to be or feel you ought to be. THE REAL YOU MUST BE THE REFERENCE POINT.

2. **Words.** The words used in the *Gregorc Style Delineator* matrix are not parallel in construction nor are they all adjectives or all nouns. This was done on purpose. Just react to the words as they are presented.*

Example

X

a. 4 sun

b. 2 moon

c. 3 stars

d. 1 clouds

3. **Rank.** Rank in order the ten sets of four words. Put a "4" in the box above the word in each set which is the best and most powerful descriptor of your SELF. Give a "3" to the word which is the next most like you, a "2" to the next and a "1" to the word which is the least descriptive of your SELF. Each word in a set must have a ranking of 4, 3, 2 or 1. No two words in a set can have the same rank.

4 = MOST descriptive of you
1 = LEAST descriptive of you

4. **React.** To rank the words in a set, react to : *first impression*. There are no "right" or "wror answers. The real, deep-down you is best reve: through a first impression. Go with it. Analyzi each group will obscure the qualities of SELF by the Delineator.

5. **Proceed.** Continue to rank all ten vertical cc of words, one set at a time.

6. **Time.** Recommended time for word ranking minutes.

7. **Start.** Turn the page and start now.

APPENDIX 20

APPENDIX 20

TEST FOLLOWING USE OF CAL AND LECTURE DELIVERED ON REQUIREMENT OF A CLASSIFICATION SCHEME

THE FOLLOWING TEST IS DESIGNED TO FIND OUT A BIT ABOUT HOW MUCH YOU HAVE LEARNED FROM USING THE CAL PACKAGE/LECTURE

NB this is not part of your formal assessment for the unit.

Section 1: GENERAL FEATURES OF CLASSIFICATION SCHEMES

1. Define what is meant by the term 'literary warrant'. Who coined the phrase? (2 marks)

2. When discussing bibliographic classification schemes what is an alternative term for **specificity**? (1 mark)

3. What subjects are covered in the Dewey Decimal Classification Main Class 400? (1 mark)

4. Why must a *bibliographic* classification scheme allow synthesis of topics? (1 mark)

5. List **five** major general bibliographic classification schemes: (5 marks)

6. Name two 'form' classes and describe how form classes should be subdivided? (2 marks)

7. Under what circumstances might you consider not classifying a library collection? (1 mark)

8. Why do we need special library classifications? (1 mark)

9. Provide an example of a special library classification scheme (1 mark)

10. What is meant by the term enumerative when applied to a classification scheme? (1 mark)

11. What is meant by the term flexibility when applied to a classification scheme? (1 mark)

12. How many main class subdivisions are provide by the Library of Congress Classification Scheme and by the Dewey Scheme, respectively (2 marks)?

13. What is meant by the term faceted when applied to a classification scheme? (1 mark)

APPENDIX 21

APPENDIX 21

TEST FOLLOWING USE OF CAL DELIVERED ON CLASSIFICATION NOTATION

THE FOLLOWING TEST IS DESIGNED TO FIND OUT A BIT ABOUT HOW MUCH YOU HAVE LEARNED FROM USING THE CAL PACKAGE

NB this is not part of your formal assessment for the unit.

1. Examine the following sequence of notation:

R	Anatomy
RA	The lower limbs
RAL	The legs
RALP	The feet
RALPX	The toes

In terms of features of notation for bibliographic classification this is an example of

(a) Hospitality
(b) Synthesis
(c) Expressiveness
(d) Literary warrant
(e) Specificity

(1 mark)

2. Name **four** types of mnemonics employed in the notation for bibliographic classification schemes. (4 marks)

1.
2.
3.
4.

3. What term is used to describe the manner in which synthesis is achieved using notation? (1 mark)

4. It is generally acknowledged that notation should be as brief as possible. How can you achieve a brief notation? (3 methods for 3 marks)

5. Examine the following sequences of notation:

1.		2.		3.	
	12		AAB		612
	15		AAC		612.1
	17		ADA		612.27
	18		ADD		614
	23		AEE		615.7

Which sequence(s) demonstrate(s) ordinal notation. Circle the appropriate response. (1 mark)

1. 1 and 3
2. 2 and 3
3. 1 and 2
4. 1 only
5. All of the sequences

6. Name two methods used by Dewey Decimal Classification to provide synthesis (2 marks)

7. What is a Cutter Number? (1 mark)

8. Name three type of mnemonic device used in classmark notation (3 marks)

9. What (briefly) do you understand by the term 'retroactive notation? (1 mark)

10. A wide range of punctuation symbols makes notation incomprehensible. Indicate clearly which of the following 3 schemes provides (a) the most and (b) the least comprehensible notation. (3 marks)

Dewey Decimal Classification
Colon Classification
The Universal Decimal Classification

1. least comprehensible:
2. comprehensible: